Original Article

Iran J Pediatr
Sep 2011; Vol 21 (No 3), Pp: 287-293

Association of Serum Alanine Aminotransferase Levels with Cardiometabolic Risk Factors in Normal-Weight and Overweight Children

Shohreh-Ghatreh Samani[1], MD; Roya Kelishadi[1,2], MD; Atoosa Adibi[3], MD; Hengameh Noori[1], BS, and Mina Moeini*[2], MD

1. Isfahan Cardiovascular Research Center, Isfahan University of Medical Sciences, Isfahan, Iran
2. Child Health Promotion Research Center, Isfahan University of Medical Sciences, Isfahan, Iran
3. Radiology Department, Isfahan University of Medical Sciences, Isfahan, Iran

Received: *Sep 22, 2010*; Final Revision: *Dec 18, 2010*; Accepted: *Feb 16, 2011*

Abstract

Objective: This study aimed to determine the prevalence of increased alanine aminotransferase (ALT), defined by a gender-specific cutoff value, among normal weight and overweight children; and to assess the relationship of increasing ALT levels with cardiometabolic risk factors.

Methods: This cross-sectional study was conducted among school students, aged 6-18 years in Isfahan, Iran. Based on the body mass index (BMI) percentiles, a group of normal-weight was compared with a group of overweight and obese students. Gender differences were considered for increased levels of ALT, i.e. 19U/L and 30U/L for girls and boys respectively.

Findings: The study participants consisted of 1172 students (56.2% girls), with a mean (SD) age of 12.57 (3.3) years. Among overweight/obese students the mean triglycerides (TG) and diastolic blood pressure was significantly higher in those with increased ALT than in those with normal ALT levels. The logistic regression analysis showed that among overweight/obese boys, for each 1 unit increase in ALT, the odds ratio (OR) of TG, total cholesterol and systolic blood pressure increased significantly. After adjusting for age, these associations remained significant, and the OR of high density lipoprotein cholesterol (HDL-c) decreased significantly. In the model adjusting for age and BMI, the ORs of TG and HDL-c remained significant. After adjusting for age and waist circumference, HDL-c was the only parameter with significant OR. Among overweight/obese girls, in all models applied, the OR was significant for TG and total cholesterol. A significant independent association was documented for waist circumference and increase in ALT after adjustment for BMI.

Conclusion: This study documented significant relationship of increased ALT levels, defined by a gender-specific cutoff point, with cardiometabolic risk factors and hypertriglyceridemic-waist phenotype in Iranian children and adolescents.

Iranian Journal of Pediatrics, Volume 21(Number 3), September 2011, Pages: 287-293

Key Words: Cardiometabolic Risk Factors; Fatty Liver; Children; Prevention

*** Corresponding Author;**
Address: Child Health Promotion Research Center, Isfahan University of Medical Sciences, Isfahan, Iran
E-mail: drm_moeini@yahoo.com

Introduction

Childhood obesity is increasing in developed and developing countries [1-3]. It is not only a public health problem, but also a clinical problem by its complications on different body organs.

Metabolic syndrome (MetS) and non- alcoholic fatty liver disease (NAFLD) are some of these health consequences [4,5]. MetS is a clustering of risk factors associated with chronic inflammation, insulin resistance, endothelial dysfunction, and cardiovascular diseases [6,7]. There is a growing body of evidence about the correlation of MetS with NAFLD [8-10].

It is suggested that fat accumulation in liver can predispose one to metabolic disorders and dyslipidemia [11]. Considering the long-term effects of NAFLD [12-15], the prevention, screening and controlling NAFLD from early life should be underscored [16]. Although liver biopsy is the gold standard diagnostic method for fatty liver [17], but given that it is an invasive method, imaging procedures and elevation of liver enzymes are usually used to detect NAFLD in population-based studies [18,19].

A study found serum triglycerides (TG) and alanine aminotransferase (ALT) are appropriate screening markers for suspected NAFLD in obese children and adolescents [20]. Usually in clinical setting, ALT level of 40 IU/L is often deemed as upper limit of the normal range in children. Some studies suggested lower cutoff values of ALT in children than in adults [21,22]. Some researchers also suggested gender differences for these levels, i.e. 19U/L and 30U/L for girls and boys respectively [4,23,24].

This study aimed to determine the prevalence of increased ALT, defined by a gender-specific cutoff value, among normal weight children and adolescents in comparison to their overweight/ obese counterparts. The other objective of this study was to assess the relationship of increasing ALT levels with cardiometabolic risk factors.

Subjects and Methods

We have previously described the methods in details [25], herein we present it in brief. In the first step of this survey, weight and height of 7554 randomly selected students, aged 6-18 years, were measured in Isfahan, Iran.

Their body mass index (BMI) was calculated as weight (Kg) divided by height squared (m^2), then they were categorized into three groups of normal weight, overweight and obese based on the BMI charts of the US centers for disease control and prevention [26]. A random sample was selected from each BMI group, and students were included in the study after obtaining written informed consents from parents and oral assents from students.

In addition to physical examination, fasting blood glucose, serum lipid profile and liver enzymes were determined among 1107 students.

ALT levels higher than 19U/L and 30U/L were considered as abnormal for girls and boys, respectively [4,23,24]. The pediatric metabolic syndrome was defined based on the modified criteria of the Adult Treatment Panel III consisting of 1) fasting TG >100 mg/dL; 2) HDL-C <50 mg/dL (except in boys aged 15-18 y, in whom the cut-off was <45 mg/dL); 3) waist circumference >75th percentile for age and gender in the population studied; 4) systolic/diastolic blood pressure >90th percentile for gender, age and height; and 5) fasting blood glucose (FBG) >100 mg/dL[27,28].

Statistical analysis: Data were analyzed by SPSS statistical software version 17.0 (SPSS Inc, Chicago, IL., USA) using Analysis of variance (ANOVA) and logistic regression analyses. In the latter analysis, each 1 unit increase in ALT was considered as an independent factor and other variables as dependent ones. Four models were applied: the first model was unadjusted; the second was adjusted for age, the third for age and BMI, and the fourth was adjusted for age and waist circumference (WC).

Findings

The study participants consisted of 1172 students (56.2% girls), without significant difference in the mean age of girls and boys (12.6±3.3 vs. 12.3±3.1 years, respectively).

Overall, 38.3% of boys were normal weight and 61.7% were overweight and obese; the

Table 1: Characteristics of study population (n=1172) according to weight status

Parameters	Boys (43.8 %)		Girls (56.2%)	
	Normal weight (38.3%)	Overweight & obese (61.7%)	Normal weight (41.1%)	Overweight & obese (58.9%)
Age (years)	12.7 (3.3)	12.7 (2.9)*	12.2 (3.5)	12.9 (3.1)*
Body mass index(kg/m²)	16.4 (2.5)	25.36.8 (4.1)*	16.9 (3.0)	24.8 (3.0)*
Waist circumference(cm)	65.4 (8.3)	88.4 (11.7)*	67.8 (9.3)	86.5 (10.5)*
Systolic blood pressure (mmHg)	97.8 (12.3)	109.0 (15.7)*	97.8 (13.9)	105.5 (13.6)*
Diastolic blood pressure (mmHg)	60.2 (9.1)	66.0 (10.7)*	61.8 (9.1)	65.2 (10.5)*
Fasting blood glucose (mg/dl)	82.7 (8.8)	82.7 (8.8)	81.2 (8.2)	82.7 (11.2)
Triglycerides(mg/dl)	93.0 (37.5)	126.1 (66.4)*	154.7 (87.8)	105.3 (45.7)*
Total cholesterol(mg/dl)	82.7 (8.8)	175.0 (33.5)*	164.4 (27.2)	174.9 (31.1)*
HDL-cholesterol(mg/dl)	48.6 (11.7)	43.4 (9.8)*	47.7 (10.7)	44.6 (10.1)*
LDL-cholesterol(mg/dl)	90.4 (21.6)	107.3 (27.9)*	96.7 (24.4)	106.2 (26.7)*
Alanine aminotransferase (U/l)	16.2 (6.7)	24.5 (11.4)*	15.7 (8.4)	19.65 (10.1)*

ALT: Alanine Aminotransferase (U/L) / HDL-C: High Density Lipoprotein Cholesterol / LDL-C: Low Density Lipoprotein Cholesterol
**P*. value <0.05

corresponding figure for girls was 41.1% and 58.9%, respectively. Except FBG, all other variables studied were significantly higher in overweight and obese group than in their normal-weight counterparts.

Table 2 presents the mean values of variables studied in normal- and overweight/obese groups with normal or increased values of ALT [4,23,24]. Among overweight/obese students, the mean BMI, WC, TG and diastolic blood pressure was

Table 2: Anthropometric and metabolic data in boys and girls according to serum levels of alanine aminotransferase

Parameters	Normal weight (n=448)				Overweight and obese (n=673)			
	Boys (n=183)		Girls (n=255)		Boys (n=303)		Girls (n=370)	
	ALT ≤30 (n=177)	ALT >30 (n=9)	ALT ≤19 (n=203)	ALT >19 (n=52)	ALT ≤30 (n=236)	ALT >30 (n=67)	ALT ≤19 (n=214)	ALT >19 (n=156)
Age (y)	11.6 (3.3)	13.0 (2.9)	12.2 (3.5)	12.1 (3.4)	12.7 (3.0)	12.7 (2.6)	13.2 (3.1)	12.5 (3.07)
Body Mass Index (kg/m2)	16.3 (2.3)	18.0 (2.5)*	16.8 (3.1)	17.1 (2.8)	12.9 (3.9)	27.1 (4.4)*	24.2 (3.9)	25.6 (3.8)*
Waist circumference (cm)	64.9 (7.7)	71.5 (8.2)*	67.4 (9.4)	68.8 (9.2)	87.0 (11.1)	93.1 (12.5)*	87.1 (10.3)	88.5 (10.5)*
Systolic Blood Pressure (mmHg)	97.6 (12.4)	97.1 (11.1)	98.1 (14.3)	97.0 (11.9)	107.8 (15.8)	112.7 (15.3)	105.9 (14.2)	105.0 (12.8)
Diastolic Blood Pressure (mmHg)	60.2 (9.2)	60.0 (7.6)	62.1 (9.07)	60.6 (9.2)	65.1 (10.0)	68.7 (12.3)*	66.0 (11.1)	64.2 (9.6)
Fasting Blood Glucose (mg/dl)	82.3 (8.6)	88.1 (12.2)	81.3 (8.3)	80.7 (7.9)	83.2 (8.4)	85.0 (8.27)	82.1 (12.5)	83.6 (9.1)
Cholesterol (mg/dl)	156.4 (25.0)	159.4 (21.6)	163.9 (27.1)	167.6 (27.9)	172.2 (34.1)	184.9 (30.22)	172.1 (32.5)	178.9 (29.0)*
HDL-C (mg/dl)	89.8 (21.8)	12.5 (88.4)	95.8 (24.2)	101.6 (24.2)	106.1 (28.5)	111.4 (25.72)	104.1 (27.4)	109.3 (25.6)
LDL-C (mg/dl)	48.9 (11.5)	46.1 (16.9)	48.6 (11.2)	44.3 (8.3)*	43.1 (9.8)	44.3 (9.9)	44.8 (9.5)	44.2 (10.9)
Triglycerides (mg/dl)	92.6 (37.5)	97.0 (43.6)	97.8 (40.1)	104.8 (46.1)	120.6 (63.2)	145.7 (67.7)*	117.5 (65.9)	133.7 (63.3)*

ALT: alanine aminotransferase (U/L) / HDL-C: High Density Lipoprotein Cholesterol / LDL-C: Low Density Lipoprotein Cholesterol
**P*. value <0.05

Table 3: Logistic Regression analysis for each 1 unit increase in alanine aminotransferase in overweight and obese boys and girls

	Model I			Model II			Model III			Model IV		
	OR	95% CI	*P*	OR	95% CI	*P*	OR	95% CI	*P*	OR	95% CI	*P*
Boys												
TG (mg/dl)	1.04	1.02-1.07	<0.001	1.04	1.02-1.07	<0.001	1.03	1.01-1.06	0.01	1.03	1.01-1.06	**0.1**
HDL (mg/dl)	0.98	0.96-1.01	0.07	0.98	0.95-1.00	0.04	0.97	0.95-1.00	0.02	0.97	0.95-0.99	**0.02**
LDL (mg/dl)	0.96	0.88-1.04	0.3	0.95	0.87-1.04	0.3	0.95	0.86-1.04	0.3	0.95	0.86-1.04	**0.3**
T.Chol (mg/dl)	1.02	1.00-1.05	0.02	1.03	1.00-1.05	0.02	1.02	1.00-1.04	0.1	1.02	1.00-1.04	**0.1**
FBG (mg/dl)	0.99	0.94-1.05	0.8	0.99	0.94-1.05	0.8	0.99	0.93-1.05	0.7	0.99	0.93-1.05	**0.7**
SBP (mmHg)	1.04	1.01-1.07	0.01	1.04	1.01-1.07	0.01	1.02	0.99-1.05	0.2	1.01	0.98-1.05	**0.4**
DBP (mmHg)	1.03	0.98-1.09	0.2	1.04	0.98-1.10	0.2	1.03	0.96-1.09	0.4	1.03	0.97-1.10	**0.3**
WC (cm)	1.03	0.98-1.07	0.3	1.03	0.98-1.08	0.2	0.97	0.93-1.03	0.3	0.96	0.90-1.02	**0.2**
Girls												
TG (mg/dl)	1.04	1.02-1.07	<0.001	1.04	1.02-1.07	0.002	1.03	1.01-1.06	0.009	1.03	1.01-1.06	**0.009**
HDL (mg/dl)	1.01	0.99-1.05	0.3	1.01	0.99-1.04	0.3	1.01	0.99-1.04	0.5	1.01	0.98-1.04	**0.4**
LDL (mg/dl)	0.96	0.88-1.06	0.5	0.97	0.88-1.06	0.5	0.95	0.85-1.05	0.3	0.95	0.86-1.06	**0.4**
T.Chol (mg/dl)	1.03	1.01-1.05	0.01	1.03	1.01-1.05	0.01	1.02	1.00-1.05	0.05	1.02	1.00-1.05	**0.04**
FBG (mg/dl)	1.02	0.99-1.07	0.2	1.03	0.99-1.07	0.2	1.62	0.98-1.07	0.3	1.02	0.98-1.07	**0.3**
SBP (mmHg)	1.01	0.96-1.05	0.8	1.00	0.96-1.05	0.8	0.99	0.99-1.05	0.8	0.99	0.95-1.05	**0.9**
DBP (mmHg)	0.98	0.91-1.07	0.7	0.99	0.91-1.07	0.7	0.93	0.81-1.07	0.3	0.97	0.87-1.08	**0.5**
WC (cm)	**1.00**	**0.95-1.05**	**0.9**	**1.00**	**0.95-1.04**	**0.8**	**0.95**	**0.90-0.99**	**0.02**	**0.92**	**0.85-0.99**	0.02

Model I: unadjusted; Model II: adjusted by age; Model III: adjusted by BMI and age; Model IV: adjusted by waist and age
OR: Odds Ration / CI: Confidence Interval / P: P value / SBP: Systolic Blood Pressure / DBP: Diastolic Blood Pressure / TG: Triglyceride/ T.Chol: Total Cholesterol/ HDL: High Density Lipoprotein/ LDL: Low Density Lipoprotein / FBG: Fasting Blood Glucose / WC: Waist Circumference

significantly higher in the overweight/obese group with increased ALT than in those with normal ALT levels.

In overweight/obese boys, the mean BMI, WC and TG increased significantly across the quartiles of ALT; among girls, this increase was also significant for FBG, total cholesterol and low density lipoprotein cholesterol (LDL-c) (Fig. 1).

Table 3 demonstrates the results of the logistic regression analysis for each 1 unit increase in ALT as an independent factor and others as dependent variables. Among normal-weight students, the only significant association was documented for WC in girls in the model adjusted for age and BMI. Among overweight/obese boys, for each 1unit increase in ALT, the ORs of TG, total cholesterol and systolic blood pressure increased significantly.

After adjusting for age, these associations remained significant, and the OR of high density lipoprotein cholesterol (HDL-c) decreased significantly. In the model adjusting for age and BMI, the ORs of TG and HDL remained significant. After adjusting for age and WC, HDL was the only parameter with significant OR. Among overweight/obese girls, in all models applied, the OR was significant for TG and total cholesterol. A significant independent association was documented for WC and increase in ALT after adjustment for BMI.

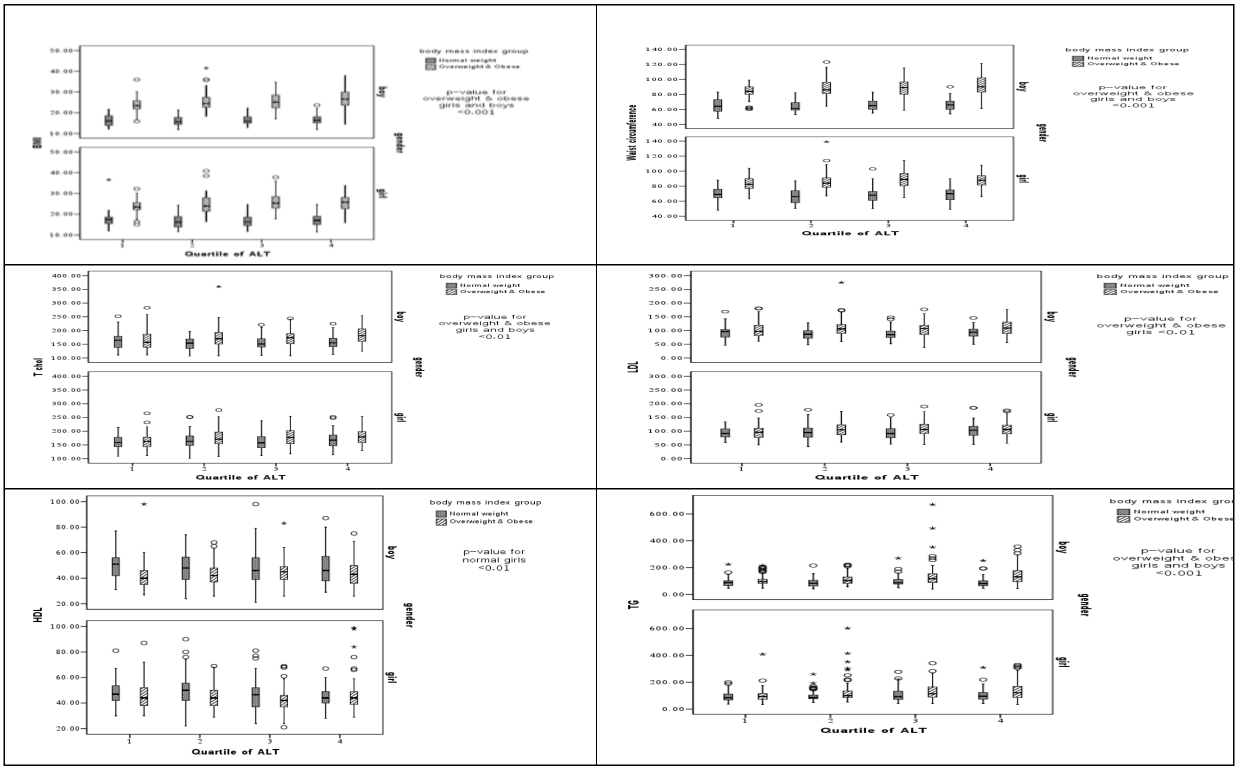

Fig. 1: Comparison of variables studied in normal-weight vs. overweigh and obese girls and boys according to alanine aminotransferase quartiles

Discussion

This study confirmed significant association of ALT levels to cardiometabolic risk factors in children and adolescents.

Although the cutoff values used to determine the increased ALT levels were different in our study with a study conducted among Korean teenagers [15], but the findings of the two studies are consistent with each other. Both studies showed significant association of increased ALT with abdominal obesity, high TG and low HDL-C; i.e. the components of the metabolic syndrome.

By using same cutoff values for ALT in a study conducted among Italian children [23], we found similar associations of increased ALT levels with the components of the metabolic syndrome.

A study among Brazilian children documented ALT as a predictive factor for the metabolic syndrome, with increasing ALT levels correlated with gradual increase in the components of the metabolic syndrome among overweight children[20].

Similar association is documented for increase in ALT and insulin resistance among Korean obese children [29].

These studies conducted in the pediatric age group are in line with studies among adult population. A study in Scottish men showed an association between the increase in ALT levels and the components of the metabolic syndrome.

Moreover, this study revealed that the diabetes risk was 3.38 times higher in men at highest ALT quartile in comparison with those at the lowest quartile [12].

The current findings might be confirmatory evidence for previous studies about the epidemiologic and clinical implication of the hypertriglyceridemic-waist phenotype in children and adolescents [30,31]. Després et al proposed that this phenotype might represent "an altered, dysfunctional, and highly lipolytic adipose tissue that is a major culprit abnormality behind the metabolic syndrome and associated cardiometabolic risk, independently from classical cardiovascular disease risk factors such as age, sex, and plasma low density lipoprotein (LDL) cholesterol levels"[32].

Given the association of overweight and lifestyle behaviors with fatty liver[33,34] and the considerably high prevalence of overweight in our community, even among young children[35], lifestyle change [36]for prevention and control of weight disorders and related complications, as fatty liver, should be underscored.

Study limitations and strengths: The main limitation of this study is its cross-sectional nature. However its strength is its population-based design and its novelty in using gender-specific cutoff values for increased ALT in Iranian children.

Conclusion

This study documented significant relationship of increased ALT levels, defined by a new and gender-specific cutoff point, with cardiometabolic risk factors in Iranian children and adolescents. It underscored the association of hypertriglyceridemic-waist phenotype with increased ALT, as a surrogate marker of fatty liver. These findings should be confirmed in future longitudinal studies.

Acknowledgment

This study was funded as a thesis by the Vice Chancellery for Research, Isfahan University of Medical Sciences, Isfahan, Iran

Conflict of Interest: None to declare

References

1. Torres DM, Harrison SA. Diagnosis and therapy of nonalcoholic steatohepatitis. *Gastroenterology* 2008;134(6):1682-98.
2. Kelishadi R. Childhood overweight, obesity, and the metabolic syndrome in developing countries. *Epidemiol Rev* 2007;29: 62-76.
3. Kelishadi R, Ardalan G, Gheiratmand R, et al. CASPIAN Study Group: Association of physical activity and dietary behaviours in relation to the body mass index in a national sample of Iranian children and adolescents: CASPIAN Study. *Bull World Health Organ* 2007;85(1):19-26.
4. Kim HC, Nam CM, Jee SH, et al. Normal serum aminotransferase concentration and risk of mortality from liver diseases: prospective cohort study. *BMJ* 2004;328(7446):983.
5. Burgert TS, Taksali SE, Dziura J, et al. Alanine aminotransferase levels and fatty liver in childhood obesity: associations with insulin resistance, adiponectin, and visceral fat. *J Clin Endocrinol Metab* 2006;91(11):4287-94.
6. Schindhelm RK, Diamant M, Bakker SJ, et al. Liver alanine aminotransferase, insulin resistance and endothelial dysfunction in normo-triglyceridaemic subjects with type 2 diabetes mellitus. *Eur J Clin Invest* 2005;35(6):369-74.
7. Musso G, Gambino R, Bo S, et al. should nonalcoholic fatty liver disease be included in the definition of metabolic syndrome? A cross-sectional comparison with Adult Treatment Panel III criteria in non obese non diabetic subjects. *Diabetes Care* 2008;31(3):562-8.
8. Marchesini G, Brizi M, Morselli-Labate AM, et al. Association of nonalcoholic fatty liver disease with insulin resistance. *Am J Med* 1999;107(5): 450-5.
9. Wilson PW, D'Agostino RB, Levy D, et al. Prediction of coronary heart disease using risk factor categories. *Circulation* 1998;97(18):1837-47.
10. Hamaguchi M, Kojima T, Itoh Y, et al. The severity of ultrasonographic findings in nonalcoholic fatty liver disease reflects the metabolic syndrome and visceral fat accumulation. *Am J Gastroenterol* 2007;102(12):2708-15.
11. Duman DG, Celikel C, Tüney D, et al. Computed tomography in nonalcoholic fatty liver disease: a useful tool for hepatosteatosis assessment? *Dig Dis Sci* 2006;51(2):346-51.
12. Sattar N, Scherbakova O, Ford I, et al. Elevated alanine aminotransferase predicts new-onset type 2 diabetes independently of classical risk factors, metabolic syndrome, and C-reactive protein in the west of Scotland coronary prevention study. *Diabetes* 2004;53(11):2855-60.
13. Vozarova B, Stefan N, Lindsay RS, et al. High alanine aminotransferase is associated with decreased hepatic insulin sensitivity and predicts the development of type 2 diabetes. *Diabetes* 2002;51(6):1889-95.
14. Oh SY, Cho YK, Kang MS, et al. The association

between increased alanine aminotransferase activity and metabolic factors in nonalcoholic fatty liver disease. *Metabolism* 2006;55(12): 1604-9.

15. Park HS, Han JH, Choi KM, Kim SM. Relation between elevated serum alanine. aminotransferase and metabolic syndrome in Korean adolescents. *Am J Clin Nutr* 2005;82(5): 1046-51.
16. Lee SW, Park SH, Kim KW, et al. Unenhanced CT for assessment of macrovesicular hepatic steatosis in living liver donors: comparison of visual grading with liver attenuation index. *Radiology* 2007;244(2):479-85.
17. Fishbein MH, Gardner KG, Potter CJ, et al. Introduction of fast MR imaging in the assessment of hepatic steatosis. *Magn Reson Imaging* 1997;15(3):287-93.
18. Bedogni G, Bellentani S, Miglioli L, et al. The Fatty Liver Index: a simple and accurate predictor of hepatic steatosis in the general population. *BMC Gastroenterol* 2006;6:33.
19. Mofrad P, Contos MJ, Haque M, et al. Clinical and histologic spectrum of nonalcoholic fatty liver disease associated with normal ALT values. *Hepatology* 2003;37(6):1286-92.
20. Oliveira AM, Oliveira N, Reis JC, et al. Triglycerides and alanine aminotransferase as screening markers for suspected fatty liver disease in obese children and adolescents. *Horm Res* 2009;71(2):83-8.
21. Jagarinec N, Flegar-Mestrić Z, Surina B, et al. Pediatric reference intervals for 34 biochemical analyses in urban school children and adolescents. *Clin Chem Lab Med* 1998;36(5):327-37.
22. Burritt MF, Slockbower JM, Forsman RW, et al. Mayo Clin Proc. Pediatric reference intervals for 19 biologic variables in healthy children. 1990; 65(3):329-36.
23. Di Bonito P, Sanguigno E, Di Fraia T et al. Association of elevated serum alanine aminotransferase with metabolic factors in obese children: sex-related analysis. *Metabolism* 2009; 58(3):368-72.
24. Prati D, Taioli E, Zanella A, et al. Updated definitions of healthy ranges for serum alanine aminotransferase levels. *Ann Intern Med* 2002; 137(1):1-10.
25. Kelishadi R, Cook SR, Adibi A, et al. Association of the components of the metabolic syndrome with non-alcoholic fatty liver disease among normal-weight, overweight and obese children and adolescents. *Diabetol Metab Syndr* 2009; 1:29.
26. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM. CDC growth charts: United States. Adv Data. 2000, 314:1-27.
27. De Ferranti SD, Gauvreau K, Ludwig DS, et al. Prevalence of the metabolic syndrome in American adolescents: findings from the Third National Health and Nutrition Examination Survey. *Circulation* 2004;110(16):2494-7.
28. Kelishadi R, Ardalan G, Gheiratmand R, Adeli K, Delavari A, Majdzadeh R;Caspian Study Group. Paediatric metabolic syndrome and associated anthropometric indices: the CASPIAN Study. Acta Paediatr. 2006;95(12):1625-34.
29. Yoo J, Lee S, Kim K, et al. Relationship between insulin resistance and serum alanine aminotransferase as a surrogate of NAFLD (nonalcoholic fatty liver disease) in obese Korean children. *Diabetes Res Clin Pract* 2008;81(3):321-6.
30. Esmaillzadeh A, Mirmiran P, Azizi F. Clustering of metabolic abnormalities in adolescents with the hypertriglyceridemic waist phenotype. *Am J Clin Nutr* 2006;83(1):36-46.
31. Alavian SM, Motlagh ME, Ardalan G, et al. Hypertriglyceridemic waist phenotype and associated lifestyle factors in a national population of youths: CASPIAN Study. *J Trop Pediatr* 2008;54(3):169-77.
32. Després JP, Cartier A, Côté M, Arsenault BJ. The concept of cardiometabolic risk: Bridging the fields of diabetology and cardiology. *Ann Med* 2008;40(7):514-23.
33. Mager DR, Patterson C, So S, et al. Dietary and physical activity patterns in children with fatty liver. *Eur J Clin Nutr* 2010;64(6):628-35.
34. Hosseini S, Mousavi S, Poursafa P, et al. Risk Score Model for Predicting Sonographic Non-alcoholic Fatty Liver Disease in Children and Adolescents. *Iran J Pediatr* 2011;21(2):181-7.
35. Motlagh ME, Kelishadi R, Amirkhani MA, et al. Double burden of nutritional disorders in young Iranian children: findings of a nationwide screening survey. *Public Health Nutr* 2011;14(4): 605-10.
36. Kelishadi R, Ziaee V, Ardalan G. A National Experience on Physical Activity Initiatives for Adolescent Girls and Their Mothers: CASPIAN Study. *Iran J Pediatr* 2010;20(4):420-6.