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Accuracy of Tri-ponderal Mass Index and Body Mass Index in Estimating Insulin Resistance, Hyperlipidemia, Impaired Liver Enzymes or Thyroid Hormone Functions and Vitamin D Level in Children and Adolescents

Short Running Title: Comparison of BMI and TRI in pediatrics

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What is already known on this topic?
Recently, the tri-ponderal mass index has been studied as an alternative to body mass index and it has been reported to be nearly stable throughout adolescence and may estimate body fat levels more accurately than body mass index especially in adolescents.

What this study adds?
This study documented the usability of the proposed TMI values in Turkish children and presented the relations between the TMI with some biochemical parameters. According to our knowledge, this may be the first study to investigate power of TMI as a prediction of liver enzymes and also the first one in Turkish children.

Abstract
Objective: Tri-ponderal mass index (TMI) has been reported to estimate body fat more accurately than body mass index (BMI). This study aimed to compare the efficacy of TMI and BMI in forecasting of insulin resistance, hyperlipidemia, impaired liver enzymes or thyroid hormone functions and vitamin D level.
Method: One hundred and forty-three overweight or obese children according to standardised BMI (BMI SDS) were studied retrospectively. TMI thresholds to diagnose overweight status were 16.0 kg/m^3 for boys, 16.8 kg/m^3 for girls and to diagnose obese status were 18.8 kg/m^3 for boys, 19.7 kg/m^3 for girls.
Results: Twenty-two overweight and 8 obese children were classified as normal when TMI was used. These 22 overweight children had 22.7% insulin resistance and insulin resistance was detected in 2 of 8 obese children with normal TMI. There was no increase in liver enzymes of any children with normal TMI. Forty-four obese children were overweight according to TMI and insulin resistance were detected in of 40.9%. Thyrotrophin-stimulating hormone were significantly higher in BMI obese when TMI classification did not effect the mean values of thyroid hormones. Vitamin D levels were same in all groups of both classifications.
Conclusion: When we use TMI, we may have a risk of skip over the insulin resistance. However, If we assume that liver enzymes are elevated as a finding of visceral adiposity, TMI can be used as an auxiliary parameter to show visceral effects of adiposity. Normal TMI may indicate that visceral organ functions have not deteriorated yet.
Keywords: Body Mass Index, hyperlipidemia, impaired liver enzymes, insulin resistance, Tri-ponderal mass index

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Introduction
Childhood obesity is a major worldwide health concern (1-3). During the last 20 years, the proportion of obese children and adolescents has significantly increased across most countries (1-3). Obesity in adolescents is a major risk factor for adulthood obesity (3). Childhood obesity is also strongly linked to comorbidities such as

hypertension, hyperlipidemia, impaired glucose metabolism and type 2 diabetes, obstructive sleep apnea, non-alcoholic fatty liver disease, and metabolic syndrome in childhood or later in life (3). Body mass index (BMI) is used to diagnose obesity in children and adolescents. Recently, the tri-ponderal mass index (TMI) has been reported to be nearly stable throughout adolescence and estimate body fat levels more accurately than BMI especially in adolescents (4). In line with the increasing interest on TMI, recently studies about TMI in both obese (4-8) and non-obese children (9) have come to the fore. The aim of this study was, to compare the efficacy of BMI and this recently proposed TMI in forecasting of insulin resistance, hyperlipidemia, impaired liver enzymes, thyroid hormone functions and vitamin D levels.

Methods

Participants

In this retrospective study, medical chart review was performed to collect data from the pediatric endocrinology outpatient clinics of Near East University, Nicosia, Northern Cyprus. The written medical records of patients were searched for all children and adolescents with the diagnosis of obesity between January 2016 and December 2017.

Initial data selection sought children and adolescents with obesity or overweight according to their standardised BMI (BMI SDS), aged 6 to18 years at their first visit to the endocrine clinic and followed at the endocrine clinic for at least 1 year. Children with BMI SDS between +1.0 and +2.0 were overweight when children with BMI SDS more than or equal to +2.0 were obese. Excluded from the study were: patients with syndromatic obesity, endocrine disorders associated with obesity (hypothyroidism, Cushing's syndrome, hypothalamic obesity postcranial surgery, etc.), or with non-endocrine chronic illness which require medications that might impact body weight (systemic steroids, psychiatric medications) and patients with missing data.

Clinical and Biochemical Parameters

Routine clinical follow-up of patients at every clinic visit (usually every 4-6 months) during a time period of study, included measurement of weight (with underwear, using a standard calibrated scale) and height (using a commercial Harpenden-Holtain stadiometer), evaluation of pubertal stage, according to the criteria of Marshall and Tanner. BMI and TMI were calculated as weight in kilograms divided by height in meters squared (kg/m^2) and as weight divided by height cubed (kg/m^3) respectively. The standard deviation score (SDS) of height, weight, and BMI were calculated according to the reported data of Neyzi for Turkish children and adolescence (10). Because of no consensus as to the cut-off value that can be used to define excess adiposity based on TMI, we used the TMI thresholds values of the study of Peterson CM that used for estimating body fat for ages 8 to 17 (4). TMI thresholds to diagnose overweight status were 16.0 kg/m^3 for boys and 16.8 kg/m^3 for girls and were 18.8 kg/m^3 for boys and 19.7 kg/m^3 for girls to diagnose obese status.

Fasting blood glucose, insulin, homeostasis model assessment insulin resistance (HOMA-IR), high (HDL) and low density (LDL) lipoprotein cholesterol, triglycerides, total cholesterol, liver function enzymes, thyroid hormones, 25-hydroxyvitamin D ($25(OH)D_3$), were evaluated. HOMA-IR was used to evaluate insulin resistance using the formula: HOMA-IR = (insulin [mU/l] × glucose [mmol/l])/22.5 (3). The HOMA-IR thresholds of Turkish children were used to diagnose insulin resistance (2.22 for prepubertal girls, 2.67 for prepubertal boys, 3.82 pubertal girls and 5.22 for pubertal boys)(11). Total cholesterol (TC) ≥ 200 mg/dl, triglyceride (TG) ≥150 mg/dl (≥ 1.69 mmol/L) were accepted as high, whereas the thresholds of liver enzymes were accepted according to laboratory references. One (rather than a sex-specific) cut-off was used for HDL-cholesterol levels (<1.03 mmol/L or <40 mg/dl) according to the International Diabetes Federation (IDF) consensus definition of metabolic syndrome in children and adolescents (12). Vitamin D status classificated as sufficiency (>50 nmol/l or >20 ng/ml), insufficiency (30–50 nmol/l or 12-20 ng/ml) and deficiency (<30 nmol/l or <12 ng/ml) based on the consensus statement of Endocrine Society (13). Abdominal ultrasound (USG) was performed for non-alcoholic fatty liver disease in patients with insulin resistance detected and / or elevated in liver enzymes.

Data Analysis

The Statistical Package for Social Sciences Software (SPSS 21, Chicago, IL, USA) was used for data analysis. All continuous variables were expressed as the mean, standard deviation, maximum and minimum values. The Kruskal-Wallis H test was used to determine if there were statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable. If the Kruskal-Wallis H led to a conclusion that there was evidence of a difference in the group means, Mann-Whitney U Test was used to determine which means among a set of means differed from the rest. Also, Mann-Whitney U Test is used to compare two sample means that come from the same population, and used to test whether two sample means are equal or not. Finally, chi-square test was the other test used in the study. Chi-square test was used for testing relationships between categorical variables from a single population. Statistical significance was defined as $p < 0.05$.

Results

A total of 143 patients were enrolled in the study. Of the total cohort, 58% of patients (n = 83) were female, 42% (n = 60) were male. The mean age of all patients was 11.1 ± 2.9 (min: 6.3; max: 17.6) years. According to

the BMI SDS, overweight group consisted of 37 patients (25.9%), while obese group consisted of 106 patients (74.1%), respectively. When the sample of study classified based on TMI thresholds, 3 groups were sampled as normal 21% (n=30), overweight 41.3% (n=59) and 37.8% (n=54) obese. Twenty-two overweight and 8 obese children were classified as normal when we used the TMI. There were no patient that TMI classified as obese while BMI SDS classified overweight. Forty-four obese children were classified as overweight according to the TMI. There were 54 (37.7%) patients who were classified as obese, based on both BMI SDS and TMI (Table 1).
The mean values of fastining blood glucose, insulin, HOMA-IR, total cholesterol, HDL, LDL, triglycerides, serum glutamic oxaloacetic transaminase (SGOT), serum glutamic-pyruvic transaminase (SGPT), 25-(OH)D_3, thyroid-stimulating hormone (TSH) and free thyroxine (fT4) were presented in Table 2. The means of serum triglyceride, SGOT and SGPT were differ within the groups according to TMI classification. The serum levels of triglyceride, SGOT, SGPT in patients with normal TMI, were significantly lower than those of both obese and overweight patients (Table 2). On the other hand, the means of fasting blood glucose and TSH levels were significantly differ between the overweight and obese patients based on BMI SDS classification (Table 2). TMI classification did not effect the mean values of thyroid hormones (Table 2). However, all of the patients with normal TMI had normal TSH values. According to the BMI, all of the patients with elevated TSH were obese (Table 3). Serum 25-(OH)D_3 levels were same in all groups according to the both classification (Table 2-3).
The rate of insulin resistance in total study group was 37.1% according to HOMA-IR thresholds of Turkish children. Based on BMI SDS, 8 of overweight patients (21.6%) and 45 of obese patients (42.5%) had insulin resistance while based on TMI, 7 (23.3%) of normal, 21 (35.5%) of overweight, 25 (46.3%) of obese patients had insulin resistance (Table 3). The frequency of insulin resistance was significantly higher in obese children than in overweight when BMI was used to classify study group (Table 3). Moreover, when we classified study group according to the BMI, another parameter that was significant between obese and overweight group was the frequency of low HDL levels. However, although it was not significantly, only the frequency of high serum glutamic oxaloacetic transaminase (SGOT) seemed to be differ within the groups classified according to the TMI (*p=0.054*) (Table 3).
Twenty-two overweight children with normal TMI had 22.7% insulin resistance, 9.1% high total cholesterol level, 50% higher LDL levels than 100 mg/dL, 4.5% low HDL and high triglyceride level. Two of 8 obese children (BMI SDS > +2) with normal TMI had insulin resistance and low HDL levels. There was no incerase in liver enzyme levels in any children with normal TMI (Table 4). Forty-four obese children who were overweight according to the TMI, had insulin resistance 40.9%, low HDL 34.1% , and at least one of elevated liver enzyme 11.4%. Insulin resistance only was detected in 46.3% of 54 patients who were obese according to the both BMI SDS and TMI (Table 4).
In all insulin resistant cases (n=53), at least one elevated liver enzyme was only detected in 7 (13.2%) patients (n of high SGPT: 5, n of high SGOT: 7). None of these 7 case had normal TMI, whereas 2 of them had overweight TMI value and 5 had obese TMI value (Table 5). These 7 cases had at least grade 2 hepatosteatosis on abdominal ultrasound. On the otherhand, only 8 (17.4%) of patients who had insulin resistance without an increase in liver enzymes (n=46) had hepatosteatosis on abdominal ultrasound (n of Grade 1 hepatosteatosis: 6, n of Grade 2 hepatosteatosis: 2). None of these patients had grade 3 stetatosis. Remarkably, none of these 8 patient had normal TMI value (Table 5).

Discussion

This study documented the usability of the proposed TMI values in Turkish children and present the relations between the TMI with some biochemical parameters. This trial compare the accuracy of TMI and BMI in forecasting of insulin resistance, hyperlipidemia, impaired liver enzymes or thyroid hormone functions and 25(OH)D_3 level. Thus, the remarkable point of the current study is the first one in Turkish children and according to our knowledge, this may also be the first study to investigate power of TMI as a prediction of liver enzymes.
Recently, the debate on overdiagnosis of the BMI came to the fore (14). If the goal is to define overweight status in children and adolescents based on percentiles of body fat or visceral adiposity, BMI SDS can be overdiagnosing adolescents as overweight (4). This overdiagnose may increase health care–relatedcosts and cause stress on both families and patients (4). So, if we use TMI, the number of children who are diagnosed as overweight or obese can decrease. This is important because adolescents may be more sensitive than adults to being classified as overweight (4). Indeed, in our study, 22 overweight and 8 obese children were classified as normal when we used the TMI and there were no any patient that TMI classified as obese while BMI SDS classified overweight. On the otherhand, when we try to prevent overdiagnosis with BMI, the risky patient should not be skipped. So, both approaches may have some risks and undesired consequences.
Two mean values which were glucose and TSH, were significantly different according to the BMI classification. Although, mean values of insulin and HOMA-IR were not significantly different between the BMI overweight and BMI obese groups, the frequency of insulin resistance according to the cut off values based on age and puberty, pointed significantly difference in these two groups. Higher fastining glucose levels in obese patients than in overweights may be an expected finding consistent with increasing insulin resistance frequency. In this

case, we can discuss that BMI may introduce insulin resistance and associated higher glucose values better than TMI. On the otherhand, according to the TMI, mean values of serum triglyceride, SGOT, SGPT in patients with normal TMI, were significantly lower than those of both obese and overweight patients. Moreover, in our study, none of insulin resistant cases with elevated liver enzymes or none of insulin resistant cases with ultrasound-proven hepatosteatosis had normal TMI. All of patients with normal TMI did not have elevated liver enzymes. Although BMI has been reported as a good predictor of elevated SGPT in adolescents before (15,16), the accuracy of the TMI in detecting impaired liver enzymes seems to be beter than BMI. It has been reported that TMI may estimate body fat percentage more accurately than BMI (4). Accordingly, all of the study findings that present the correlation between TMI and liver enzymes or hepatosteatosis can be considered to support this recent information of estimation body fat percentage. If we assume that a gold standart Dual-energy x-ray absorptiometry is not always practical to secreening the percentage of body fat especially in children, this simple calculation of TMI may support us a new practical approach to have a flash of insight into the risk of increase in body fat. Moreover, TMI offers certain cut off values and does not need age-specific percentiles like as BMI, in this way it offers a way out of this problem and provides ease of use (4). This may be particularly helpful in identifying a child with a higher risk of visceral adiposity and may also be helpful in referring these risky patients to the pediatric endocrine clinics. Conversely, some criticism also exists regarding TMI usage (5,6). It has been also reported that fat distribution might be more important than body fat percentage in determining adult obesity-related outcomes such as Type 2 diabetes and TMI does not account for fat distribution without distinguishing fat mass from muscle mass (5). Moreover, in contrast to TMI supported studies, BMI SDS, followed by BMI and waist circumference have also been reported the most relevant anthropometric markers to predict metabolic risk in youth and these markers have been presented as better than TMI (6).

Although the frequency of insulin resistance in all patients was 37.1%, at least one high liver enzyme or ultrasound-proven hepatosteatosis were only detected in 7 and 8 insulin resistant cases respectively. This means that insulin resistance always may not correlate with visceral adiposity which causes organ damage or dysfunction. Moreover, the frequency of insulin resistance was close to 50% in patients who were evaluated as obese in both classifications. From this, it can be assumed that there may be other factors contributing to the formation of both insulin resistance and visceral adiposity except weight gain versus height^n. The reasons for this difference may reside in differences in genetic, ethnicity, socioeconomic status, and environment, and the interactions among these variables (4). However, this study highlighted that this multifactorial effected insulin resistance may be more correlated with weight versus height^2 whereas weight versus height^3 may be more sensitive to detect multifactorial caused visceral adiposity.

The current study also tried to demostrate the relation between serum lipid levels and weight versus height^n. Only the frequency of low HDL levels was detected as correlated with BMI while the mean values of triglycerides were significantly different due to the TMI classification. However, lots of the studies have been reported for the association of BMI and lipid levels in children (17-20). Although a statistically significant association between LDL levels and BMI has been determined before in a population based cross-sectional study (17) or BMI correctly identified 77% of the total dyslipidemic disorders in obese children (20), our study could not state any relation between both BMI or TMI and LDL levels or total dyslipidemic disorders. But, the current study was only designed from overweight and obese children according to the BMI. Perhaps increasing the sample size and the inclusion of children with normal BMI can causes different results on lipid abnormalities.

In addition, this study is the first study to test the relation between vitamin D levels and thyroid hormone functions with TMI classification. However, in the current study, no any correlations between vitamin D levels and weight versus height^2 or height^3 were detected. Subclinical hypothyroidism is defined as elevated TSH levels with the normal concentrations of thyroxine (T4) or fT4 (21). Subclinical hypothyroidism has known as common in the obese group (21). Regarding this, the results pointed that only the TSH levels were related with weight gain versus height^2. According to the BMI, all of the patients with elevated TSH were obese. However, all of the patients with normal TMI had normal TSH values. This may point that normal TMI can also mean thyroid gland functions have not impaired yet. So, this issue is still open to study and discussion.

Limitations of the Study

The nature of this study required us to rely on data from medical records. Retrospective design and small sample size were the main limitations of our study. In this retrospective study, waist circumference data could not be evaluated from records that were simply missing these values. The measurements of blood pressure were not assessed in the study because the results might be unreliable according to the suboptimal conditions (not being measurements when subjects were seated and after a 5-minute rest, using an appropriately sized cuff) and could not excluded white-coat effect. Instead of waist circumference and blood pressure measurements, we used the TMI, a new parameter found to estimate body fat levels or metabolic condition. In addition, abdominal ultrasound results were limited to only the patients with insulin resistance because of cost-effectivity and prevention of any financial burden in non risky patients.

Conclusion

In conclusion, when we use TMI, we may have a risk of skip over the insulin resistance. However, If we assume that liver enzymes are elevated as a finding of visceral adiposity, TMI can be used as an auxiliary parameter to show visceral effects of adiposity. Normal TMI may indicate that visceral organ functions have not deteriorated or visceral organ damage has not started yet. However, we recommend that BMI and TMI may have different advantages and it would be more appropriate to use them together in the clinical practise. Overall, there is a need for more studies based on TMI effectivity and discovery of both national and international standards such as WHO BMI reference percentiles for TMI normals.

Ethics

Ethics Committee Approval and Consent Form: Since the study was performed respectively, ethics committee approval and patient informed consent form were not needed.

Authorship Contributions

Surgical and Medical Practices: Nese Akcan, Ruveyde Bundak
Concept: Nese Akcan, Ruveyde Bundak
Design: Nese Akcan, Ruveyde Bundak
Data Collection or Processing: Nese Akcan, Ruveyde Bundak
Analysis or Interpretation: Nese Akcan, Ruveyde Bundak
Literature Search: Nese Akcan, Ruveyde Bundak
Writing: Nese Akcan, Ruveyde Bundak
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Table 1. Distribution of groups according to BMI and TMI

		TMI Group			
		Normal	Overweight	Obese	Total
BMI Group	Overweight	22	15	0	37
	Obese	8	44	54	106
	Total	30	59	54	143

BMI: Body mass index, TMI: Tri-ponderal mass index

Table 2. The mean values of variables in study sample, and in classified groups based on TMI and BMI sds

	TMI Group					BMI Group		
	Normal	OW	OB	*p*	Total	OW	OB	*p*
BG	93.7±5.6	90.7±8.0	91.1±7.0	*0.17*	91.5±7.2	94.5±6.2	90.4±±7.3	**0.00*
Insulin	13.8±6.8	15.9±7.3	20.6±15	*0.13*	*17.2*±11.1	14.8±7.4	18.0±2.0	*0.18*
HOMA-IR	3.3±1.7	3.6±1.6	4.7±3.5	*0.28*	4.0±2.6	3.5±1.8	4.1 ±2.8	*0.29*
TC	162.9±28.3	163.1±31.1	164.6±31.7	*0.94*	*163.6*±30.6	164.1±30.3	163.5±30.8	*0.90*
HDL	48.7±9.0	46.8±10.4	47.5±12.0	*0.74*	*47.5*±10.8	49.8±8.9	46.7±11.3	*0.10*
LDL	100.1±27.3	97.9±25.9	98.7±28.5	*0.17*	*98.7*±27.0	100±27	98.1±27.1	*0.73*
TG	75.4±34.7	99.3±54.8	97.6±44.6	**0.04*	*93.7*±47.86	79.67±30.9	98.4±51.6	*0.09*
SGOT	19.7±4.3	24.7±13.0	27.5±14.7	**0.00*	*24.8*±12.8	21.9±5.7	25.8±14.3	*0.43*
SGPT	18.0±7.3	28.0±26.96	33.3±27.28	**0.00*	*28.0*±24.9	22±11.1	30±27.8	*0.07*
Vit D_3	23.7±0.1	21.6±10.5	23.3±8.7	*0.45*	*22.7*±9.5	24.4±11.3	22±8.8	*0.27*
TSH	2.1±0.9	2.5±1.5	2.9±1.7	*0.21*	*2.6*±1.5	2±0.8	2.8±1.7	*0.03**
fT4	1.6±2.6	1.4±2.2	1.4±2.5	*0.91*	*1.4*±2.4	1.4±2.3	1.4±2.4	*0.99*

Kruskal-Wallis H, Mann-Whitney U
**statistically significant*

BG:Fasting blood glucose, BMI:Body mass index, fT4: Free thyroxine, HDL: High density lipoprotein, HOMA-IR: Homeostasis model assessment insulin resistance, LDL: Low density lipoprotein, OB: Obese, OW: Overweight, SGOT: Serum glutamic oxaloacetic transaminase, SGPT: Serum glutamic-pyruvic transaminase, TMI: Tri-ponderal mass index, TSH: Thyroid stimulating hormone, Vit D_3: 25-hydroxyvitamin D

Table 3. Frequency of pathologic biochemical parameters according to BMI and BMI groups

		TMI Group (n)					BMI Group (n)			
		Normal	OW	OB	Total	*p*	OW	OB	Total	*p*
IR	(+)	7	21	25	53		8	45	53	
	(-)	23	38	29	90	*0.18*	29	61	90	**0.024*
	Total	30	59	54	143		37	106	143	
High Total cholesterol (>200 mg/dl)	(+)	2	9	7	18		4	14	18	
	(-)	28	50	47	125	*0.47*	33	92	125	*0.78*
	Total	30	59	54	143		37	106	143	
Low HDL (<40 mg/dl)	(+)	3	18	14	35		4	31	35	
	(-)	27	41	40	108	*0.1*	33	75	108	**0.02*
	Total	30	59	54	143		37	106	143	
High LDL (>100 mg/dl)	(+)	14	21	23	58		16	42	58	
	(-)	16	38	31	85	*0.86*	21	64	85	*0.85*
	Total	30	59	54	135		37	106	143	
High Triglyceride (>150 mg/dl)	(+)	2	7	9	18		2	16	18	
	(-)	28	52	45	125	*0.42*	35	90	12	*0.14*
	Total	30	59	54	143		37	106	143	
High SGOT	(+)	0	5	9	14		1	13	14	
	(-)	30	54	45	129	*0.054*	36	93	129	*0.1*
	Total	30	59	54	143		37	106	143	
High SGPT	(+)	0	4	5	9		1	8	9	
	(-)	30	55	49	134	*0.26*	36	98	134	*0.32*
	Total	30	59	54	143		37	106	143	
$25(OH)D_3$	N	18	26	25	69	*0.65*	22	47	69	*0.32*
	MD	9	24	20	53		11	42	53	
	SD	3	9	9	21		4	17	21	
	Total	30	59	54	143		37	106	143	
High TSH	(+)	0	3	4	7	*0.26*	0	7	7	*0,09*
	(-)	30	56	50	136		37	99	136	
	Total	30	59	54	143		37	106	143	

*Chi-Square Test * statistically significant*

BMI: Body Mass Index, High LDL : Low density lipoprotein >100 mg/dl, High TC: Total cholesterol >200 mg/dl, High TG:Triglyceride >150 mg/dl, IR: Insulin Resistance According to HOMA-IR thresholds of Turkish children, LE: liver enzyme, Low HDL: High density lipoprotein <40 mg/dl, MD: Mild deficiency, SD: Severe deficiency, Serum glutamic oxaloacetic transaminase (SGOT), Serum glutamic-pyruvic transaminase (SGPT),

OW: Overweight, TMI: tri-ponderal mass index, TSH: Thyrotrophin-Stimulating Hormone, 25(OH)D3: 25-hydroxyvitamin D

Table 4. Comparison of variables between groups according to the group combinations of BMI and TMI

		Group Combinations				
	n (%)	TMI Normal & BMI OW	TMI Normal & BMI OB	TMI OW & BMI OW	TMI OW & BMI OB	TMI OB & BMI OB
IR	(+)	5 (22.7%)	2 (25%)	3 (20%)	18 (40.9%)	25 (46.3%)
	(-)	17 (72.7%)	6 (75%)	12 (80%)	26 (59.1%)	29 (53.7%)
High TC	(+)	2 (9.1%)	0	2 (13.3%)	7 (15.9%)	7 (13%)
	(-)	20 (90.9%)	8 (100%)	13 (86.7%)	37 (84.1%)	47 (87%)
Low HDL	(+)	1 (4.5%)	2 (25%)	3 (20%)	15 (34.1%)	14 (25.9%)
	(-)	21 (95.5%)	6 (75%)	12 (80%)	29 (65.9%)	40 (74.1%)
High LDL	(+)	11 (50 %)	3 (37.5%)	5 (33.3%)	16 (36.4%)	23 (42.6%)
	(-)	11 (50 %)	5 (62.5%)	10 (66.6%)	28 (63.6%)	31 (57.4%)
High TG	(+)	1 (4.5%)	1 (12.5%)	1 (6.7%)	6 (13.6%)	9 (16.7%)
	(-)	21 (95.5%)	7 (87.5%)	14 (93.7%)	38 (86.4%)	45 (83.3%)
High SGOT	(+)	0 (0%)	0 (0%)	1 (6.7%)	4 (9.1%)	9 (16.7%)
	(-)	22 (100%)	8 (100%)	14 (93.7%)	40 (90.9%)	45 (83.3%)
High SGPT	(+)	0 (0%)	0 (0%)	1 (6.7%)	3 (6.8%)	5 (9.3%)
	(-)	22 (100%)	8 (100%)	14 (93.7%)	41 (93.2%)	49 (90.7%)
At least 1 high LE	(+)	0 (0%)	0 (0%)	1 (6.7%)	5 (11.4%)	9 (16.7%)
	(-)	22 (100%)	8 (100%)	14 (93.7%)	39 (88.6%)	45 (83.3%)
Total		22	8	15	44	54

BMI: Body mass index, High LDL: Low density lipoprotein >100 mg/dl, High TC: Total cholesterol >200 mg/dl, High TG:Triglyceride >150 mg/dl, IR: Insulin resistance according to HOMA-IR thresholds of Turkish children, LE: liver enzyme, Low HDL: High density lipoprotein <40 mg/dl, SGOT: Serum glutamic oxaloacetic transaminase, SGPT: Serum glutamic-pyruvic transaminase, OW: Overweight, TMI:Tri-ponderal mass index

Table 5. Frequency of high liver enzymes and hepatosteatosis in insulin resistant cases

			TMI group									
			Normal		OW			Obese				Total
HS Grade			***0***	***1***	***0***	***1***	***2***	***0***	***1***	***2***	***3***	
IR (+) (n)			7		21			25				53
At least 1 LE high (n)		**Yes**	0	0	0	2	0	0	0	3	2	7
		No	7	0	17	1	1	14	5	1	0	46

HS: Hepatosteatosis, IR: Insulin resistance according to HOMA-IR thresholds of Turkish children, OW: Overweight, TMI: tri-ponderal mass index