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Relation between severity of NAFLD and insulin resistance in obese children.

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Abstract

Background: With increasing prevalence of childhood obesity worldwide, Non-Alcoholic Fatty Liver Disease (NAFLD) became the most common cause of chronic liver disease in obese children. Insulin resistance is the main risk factor of NAFLD. NAFLD is asymptomatic in early stages. Early diagnosis and treatment of risk factor is essential in treatment and slowing down the disease progression.
Aim: This study was designed to detect the relationship between severity of fatty liver and insulin resistance.
Methods: This cross sectional study was conducted on 20 obese children with NAFLD aged from 4-12 years old. All children were subjected to full medical, dietetic history, full anthropometric measurements including weight, height, BMI, waist circumference, hip circumference, Waist to Hip Ratio (WHR), Waist to Height Ratio (WHtR), body composition, laboratory investigations including fasting glucose, fasting insulin and HOMA-IR was calculated and abdominal ultrasound .
Results: 80% of the study group was males and 20% were females. The prevalence of grade 1 mild steatosis was 75% and grade 2 moderate steatosis was 25%. And 46.7% of children with grade 1 steatosis had moderate insulin resistance and 6.7% had severed insulin resistance. 100% of children with grade 2 steatosis have severed insulin resistance. Waist Hip Ratio (WHR) showed highly statistically significant association with NAFLD grade with p value (p<0.001), also Waist Height Ratio (WHtR) was highly statistical significant associated with NAFLD grade with p value (p<0.001). Also there was a statistically significant positive correlation between WHR and WHtR with fasting insulin and HOMA IR. In the study group, there was highly positive significant correlation between NAFLD grades and fasting insulin level and HOMA-IR with p value (p<0.001), but there was non-significant correlation between NAFLD grades and fasting glucose level.
Conclusion: HOMA-IR has highly significant relation with NAFLD grade so, early detection of steatosis by HOMA-IR calculation is very important to prevent progression of liver disease.

Keywords: NAFLD, HOMA-IR, WHR, WHtR.

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Introduction

Childhood obesity became a worldwide epidemic, 39 million children under 5 worldwide were overweight or obese in 2020, and over 340 million children and adolescents aged 5-19 were overweight or obese in 2016 Obesity is classified according to etiological factors into endogenous and exogenous obesity, about 90% of diagnosed cases of obesity are exogenous and only 10% are endogenous [1,2].

Exogenous obesity occurs due to increased intake of high energy food with lack of physical activity due to sedentary lifestyle including TV watching and using phones all the day endogenous obesity is associated with specific causes which can be suspected or eliminated by taking detailed history and physical examination [3]. Metabolic Syndrome (MetS) or insulin resistance syndrome is considered a worldwide epidemic. It refers to a cluster of interconnected factors that increase risk of Coronary Heart Diseases (CHD), cardiovascular atherosclerotic diseases and diabetes mellitus type 2 [4].

Insulin Resistance (IR) is a growing concern in childhood obesity, although not all obese people are insulin resistant and IR may also occur in non-obese children and adults. IR have an important role in the Metabolic Syndrome (MS) and most likely a link between obesity and type 2 diabetes. It is important to identify children at risk before clinical symptoms occur [5].

IR is the failure of insulin to adequately promote peripheral glucose uptake and the suppression of hepatic glucose production, resulting in hyperglycemia a condition described as insulin resistance. Insulin resistance syndrome has a broad clinical spectrum including obesity, glucose intolerance, diabetes, and the metabolic syndrome [6].

Independent of the relation between total body fat and insulin resistance, increased abdominal visceral adipose tissue in obese youth is associated with decreased insulin sensitivity [7]. Waist Circumference (WC) has a higher correlation than BMI with insulin resistance and lipid metabolism, Waist Circumference to Height ratio (WHtr) is also considered age independent method to identify adult as well as children risk for insulin resistance [8]. Ectopic deposition of fat in the liver is also associated with insulin resistance in subjects with obesity [7]. Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) is the most widely used simple technique for assessing insulin resistance in clinical research and practice which is based on fasting glucose and insulin measurements [9].

NAFLD is a pathological condition characterized by Triglycerides (TG) deposition in liver more than 5% of its total weight [10]. It is the most common cause of liver disease in children [11].

Its high prevalence is mostly due to epidemicity of childhood obesity, sedentary life style and unhealthy dietary pattern worldwide [12]. Recent estimates indicate that the global prevalence of NAFLD is 25%, with the highest prevalence in the Middle East and South America and the lowest in Africa [13].

The term NAFLD include a range of liver diseases where the first stage is charcterized by simple steatosis and liver fat accumulation in the hepatocytes [14], the second stage is Non-Alcoholic Steatohepatitis (NASH) which is characterized by hepatic cellular injury as a result of inflammation, ballooning and collagen deposition.

NASH by the time can progress and cause cirrhosis and liver cell failure [10]. NAFLD involves hepatic steatosis, due to lipid accumulation arising from excessive influx of fatty acids from endogenous fat depots, excess consumption of dietary fat, and hepatic *De Novo* Lipogenesis (DNL). NASH is characterized by inflammation, oxidative stress, mitochondrial dysfunction, and fibrosis [15].

The single and main risk factor for pediatric NAFLD is obesity, with an estimated prevalence in overweight and obese children and adolescent of 50%–80% compared to 2%–7% in children of normal weight [16].

Obesity and type II diabetes associated with hyperinsulinemia and IR, may inhibit fatty acid oxidation and increase the presentation of fatty acids to the liver [17].

The gold standard for confirmation of NAFLD is histological examination of liver tissue obtained by biopsy, as it rules out other causes of liver dysfunction [18], but there are predicting biomarkers as NAFLD is likely present in obese children who have ALT values that are 2-fold higher than the sex-specific normal range [18].

Although limited sensitivity, abdominal ultrasound and liver function tests remain the first choice in diagnosing NAFLD in children [19].

Subjects and Methods

Patients and study design

This cross sectional study included 20 obese children with NAFLD from nutrition clinic, pediatrics hospital at Ain Shams University in the period between April 2019 and June 2021. The sample size was calculated using PASS program setting alpha error at 5% and confidence interval width at 0.1.

It was calculated according to the results of a previous study Bedogni et al. [21] which showed the prescence of NAFLD is 2.3% of cases. So the needed sample size was 15 cases taking in consideration 20% dropout rate.

The children age ranged between 5 and 12 years. All patients were randomly selected and had been screened by doing pelviabdominal ultrasound to detect patients with fatty liver. Children with secondary obesity such as steroid treatment, hypothyroidism, cushing syndrome were excluded.

Methods

All patients were subjected to the following

Full medical history including age of onset of obesity, family history of similar cases and history of any medications.

Full dietetic history including 24 hrs recalls, Dietary recall included breakfast, snack, lunch and dinner.

Full Anthropometric measures including: weight, height, BMI, waist circumference, hip circumference, Waist to Hip Ratio (WHR), Waist to Height Ratio (WHtR).

Weight in Kg: It was measured by a beam a mechanical weight scale ZT-160. The subject stood bare footed on the center of the platform without touching or leaning on anything, wearing the least possible clothes, reading was taken to the nearest 0.1 kg. Values were put on growth curves to 2010 CDC growth charts, created by the National Centre for Health Statistics (NCHS), Z scores.

Height (Ht) in cm: Height was measured by stadiometer (seca 217), The patient stood in an upright position barefoot on the base plate, with his feet parallel, and his heels, buttocks, shoulders and back of the head touching the stadiometer and the arms were hanging extended on side.

The measuring arm was took down to the subject`s head which is held comfortably erect. The red cursor gave the accurate measurement of the height and the reading was taken to the nearest millimeter.

Values were put on growth curves to 2010 CDC growth charts, created by the National Centre for Health Statistics (NCHS), Z scores.

Body mass index: It was calculated according to the equation weight in kg/height in meters.

Waist circumference: Waist circumference was measured by a flexible tape measure in a horizontal position parallel to the ground, touching the skin, following the contours, but not compressing the underlying tissue.
The flexible tape was positioned midway between lower rib and the iliac crest. The

tape was located evenly around the waist at this position. Reading had been taken to the nearest millimeter at the end of normal expiration.

Hip circumference: Children were in a relaxed standing position and their feet were together and the gluteal muscle was relaxed. A flexible tape was used to measure at the level of the greater posterior protuberance of the buttocks which corresponds anteriorly to about the level of symphysis pubis around the hips from the side, the stub of the tape was held in the right hand while the left hand adjust the tape level.

Waist-to-Hip Ratio (WHR): It gives idea about central distribution of fat, A WHR of 0.85 or more is significant in females and ratio of 0.95 or more for males, the only limitation of WHR is the chance of error due to thick muscle mass and large hip bone in some people which leads to increased hip circumference [22].

Waist to Height Ratio (WHtR): The ratio between Waist and Height (WHtR), both measured in centimeters, was calculated and a cutoff of 0.5 used to differentiate low WHtR from high WHtR [23]. WHtR>-0.5 indicates central obesity, WHtR<0.5 normal [24].

Body composition

It has been done by Tanita SC-330P scale with its integral printer which gives an accurate measurements and body composition analysis data. The user set-up process the analyzer for the health and fitness facility parameters. A handy analysis of the client's key measurements appears on the bottom of the print out giving an instant consultation tool. Analysis data will be transferred automatically to a computer. It was used with TIGMON health monitor software.

The SC 330 was automatically set-up for personalized patient studies, capturing measurements and trend results in a variety of reporting formats. Analysis includes weight (kg/lbs), BMI, body fat %, body fat mass, fat free mass, muscle mass, total body water, bone mass, visceral fat rating, metabolic age and basal metabolic rate.

Laboratory investigations

The 5 ml of venous blood was collected from each patient and controls. They were asked to be fasting for at least 6-8 hours. Blood samples were allowed to clot for 10 minutes and then centrifuged for 15 minutes at 1500 Xg, and the serum was collected.

Fasting blood glucose was measured using the hexokinase/glucose-6-phosphate dehydrogenase method on Beckman AU480 automated analyzer (Beckman-Coulter, Hialeah, USA)

Serum insulin was measured by electro chemiluminescence method (ADVIA Centaur CP, Siemens, Germany)

HOMA IR as a marker of insulin resistance was calculated by the homeostatic method using standard formulae for calculation (HOMA=I0 × G0/405) [25].

Radiological investigations

Liver ultrasonography should be performed by an experienced radiologist. Using GE healthcare LOGIQ 9 machine with 3-5 HZ curvilinear probe. Steatosis will be graded by a validated score [26].

Grade 0: Absent steatosis which defined as normal liver echo-texture

Grade 1: Mild steatosis as slight and diffuse increase in fine parenchymal echoes with normal visualization of diaphragm and portal vein borders

Grade 2: Moderate steatosis as moderate and diffuse increase in fine echoes with slightly impaired visualization of diaphragm and portal vein borders

Grade 3: Sever steatosis as fine echoes with poor or no visualization of diaphragm, portal vein borders and posterior portion of the right lobe.

Ethical approval

An informed consent was obtained from caregivers before enrollment in the study according to the faculty of medicine, Ain shams university research ethical committee.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean ± Standard Deviation (SD). Qualitative data were expressed as frequency and percentage.

The following tests were done:

Independent-samples t-test of significance was used when comparing between two means.

Mann Whitney U-test: for two-group comparisons in non-parametric data.

Chi-square (x^2) test of significance was used in order to compare proportions between qualitative parameters.

Fisher's exact test: was used to examine the relationship between two qualitative variables when the expected count is less than 5 in more than 20% of cells, while Fisher's exact test is more accurate than the chi-squared test when the expected numbers are small.

Spearman's rank correlation coefficient (rs) was used to assess the degree of association between two sets of variables if one or both of them was skewed.

Value of "r" ranges from -1 to 1

0=no linear correlation; 1=perfect positive correlation; -1=perfect negative correlation

Positive: Increase in the independent variable leads to increase in the dependent variable.

Negative: Increase in the independent variable leads to decrease in the dependent.

Scatter plot: A graph in which the values of two variables are plotted along two axes, the pattern of the resulting points revealing correlation present.

The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following:

Probability (P-value)

P-value <0.05 was considered significant.

P-value <0.001 was considered as highly significant.

P-value >0.05 was considered insignificant.

Results

Total number of the study population was 20 children divided into two groups according the grade of fatty liver, 15 children (75%) had mild steatosis (Grade 1 NAFLD) and 5 children (25%) had moderate steatosis (Grade 2 NAFLD).

Age of the study population ranged from 5 to 12 years with mean ± SD (10.10 ± 2.10). 6 children (30%) were <10 years and 14 children (70%) were ≥ 10 years. As regards sex distribution, there was male predominance as 11 were males with percentage 55% and 9 were females with percentage 45%. Weight of the study population ranged from 27.5–96 kg with mean ± SD (57.19 ± 17.73). 3 children (15%) were <90th%, 4 children (20%) were between 90th-<95th% and 13 children (65%) were ≥ 95th%. As for the weight z-score, it ranged between 1.04 and 3.12 with mean ± SD (2.13 ± 0.65).

Regarding height, it ranged from 1.05–1.57 m with mean ± SD (1.40 ± 0.14). There were 5 children (25.0%) <25th%, 5 children (25.0%) were between 25th-<50th%, 4 children (20.0%) were between 50th-<75th%, 3 children (15.0%) were between 75th-<95th% and 3 children (15.0%) were ≥ 95th%. Height z-score ranged between -1.36 and 2.13 with mean ± SD (0.13 ± 1.08). As for BMI, it ranged from 24.5 to 40 with mean ± SD (28.49 ± 4.50); and the z-score ranged between 1.72 and 2.90 with mean ± SD (2.28 ± 0.34). All children were obese. Concerning WHR and WHtR distribution among the study population, they are shown in Table 1.

WHR and WHtR		
WHR	Range	0.87–1.02
	Mean ± SD	0.94 ± 0.05
	Median	0.94
WHtR	Range	0.55-0.83
	Mean ± SD	0.66 ± 0.08
	Median	0.67

Table 1. WHR and WHtR distribution among the study population.

As regard fat mass distribution among the study population, it ranged from 10–45.7 with mean ± SD (22.48 ± 8.44). The body fat analysis % ranged from 12–49.1 with mean ± SD (36.81 ± 4.44).

There were 4 patients (20.0%) with increased fat % and 16 children (80.0%) were above 33% fat (Obesity). Fasting glucose level ranged from 87–125 mg/dl with mean ± SD (105.45 ± 12.42).

Normal fasting glucose level was found in 9 children (45%), while pre-diabetic level was found in 11 children (55%).

As regards fasting insulin it ranged from 4.5-46.8 mIU/ml with mean ± SD (17.67 ± 11.45).
9 children (45%) showed normal fasting insulin level, while 11 children (55%) showed abnormal level.
Concerning HOMA IR distribution among the study population, it is shown in Figure 1 and Figure 2 shows NAFLD grade distribution among the study population.

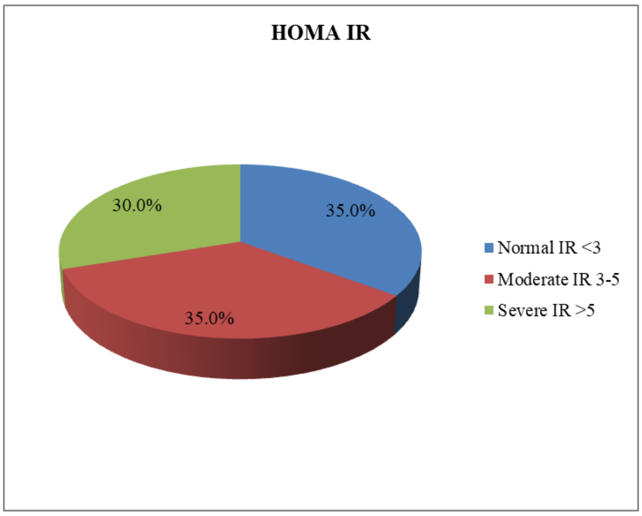

Figure 1. Pie chart of HOMA IR distribution among the study population.

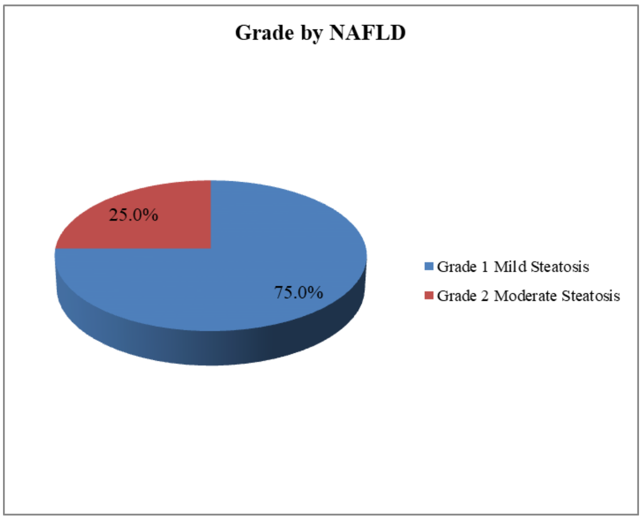

Figure 2. Pie chart of NAFLD grade distribution among the study population.

There was no statistical significant association between NAFLD grade and age and sex of the study population, with p-value >0.05.

Also, there was no statistical significant association between NAFLD grade and wt., Ht. or BMI of the study population with p-value >0.05.

There was a highly significant association between NAFLD grades and WHR and WHtR with p value (p<0.001) as shown in Table 2.

There was no statistically significant association between NAFLD grades and body composition as regards fat mass and body fat analysis %, with p-value >0.05.
There was a statistically significant association between NAFLD grade and

		Grade 1 mild steatosis (n=15)	Grade 2 moderate steatosis (n=5)	t-test	p-value
WHR	Mean ± SD	0.91 ± 0.04	1.00 ± 0.03	-4.378	<0.001**
	Range	0.87-0.99	0.95-1.02		
WHtR	Mean ± SD	0.62 ± 0.05	0.77 ± 0.06	-5.388	<0.001**
	Range	0.55-0.69	0.71-0.83		

Table 2. Association between NAFLD grade and WHR and WHtR of the study population.

There was highly statistically significant positive correlation between WHR and WHtR with fasting insulin with p-value <0.001, and r-value 0.889 and 0.925 respectively. fasting insulin level with p-value 0.020. Moreover, there was a highly statistically significant association between NAFLD grade and HOMA IR with p-value (p<0.001). On the other hand, association between fasting glucose level and NAFLD grades was non-significant with p-value >0.05. All is shown in Table 3.

		Grade 1 Mild Steatosis (n=15)	Grade 2 Moderate Steatosis (n=5)	Test	p-value
Fasting glucose (mg/dl)	Normal 70-100	8 (53.3%)	1 (20.0%)	FE	0.194
	Pre diabetes 101-125	7 (46.7%)	4 (80.0%)		
Fasting insulin (mIU/ml)	Normal 1-15	9 (60.0%)	0 (0.0%)	FE	0.020*
	>15 Abnormal	6 (40.0%)	5 (100.0%)		
HOMA IR	Normal IR <3	7 (46.7%)	0 (0.0%)	FE=15.56	<0.001**
	Moderate IR 3-5	7 (46.7%)	0 (0.0%)		
	Severe >5	1 (6.7%)	5 (100.0%)		

Table 3. Association between NAFLD grades and fasting glucose level (mg/dl), fasting insulin level (mIU/ml) and HOMA IR of the study population.

Also there was highly statistical significant positive correlation between WHR and WHtR with HOMA IR, with p-value <0.001 and r-value 0.8686 and 0.925 respectively.

There was a statistically significant positive correlation between WHR and WHtR with fasting insulin with p-value <0.001, and r-value 0.889 and 0.925 respectively. Also there was highly statistical significant positive correlation between WHR and WHtR with HOMA IR, with p-value <0.001 and r-value 0.8686 and 0.925 respectively.Moreover, there was highly significant positive correlation between WHR, WHtR and NAFLD grade in the study population with p-value (<0.001) and r-value 0.718 and 0.786 respectively.
Correlation between NAFLD Grades and the body composition of the study population as regards fat mass and body fat

analysis, showed no significant correlation. When NAFLD Grades were correlated with fasting glucose level (mg/dl), fasting insulin level (miu/ml) and HOMA IR of the study population, there were no significant correlation between NAFLD grades and fasting glucose level with r-value 0.169 and p value 0.475, but there was high significant positive correlation between NAFLD grade and fasting insulin level, and HOMA IR with p-value <0.001 as shown in Figures 3 and 4.

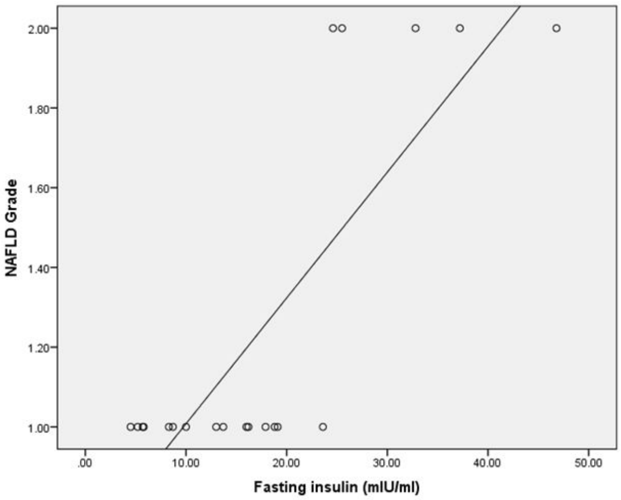

Figure 3. Correlation between NAFLD grade and fasting insulin level.

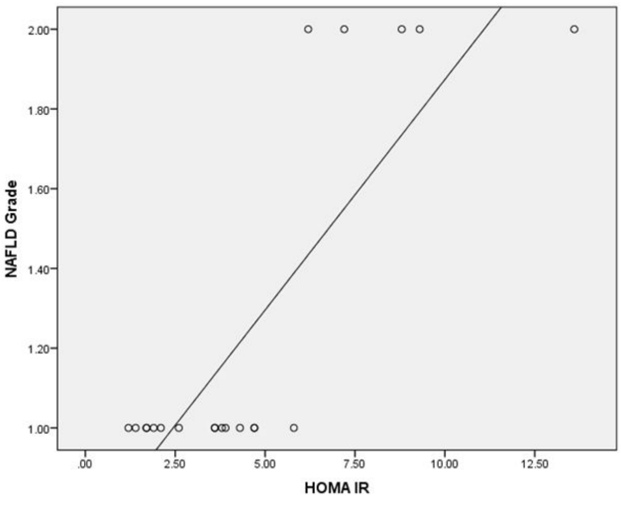

Figure 4. Correlation between NAFLD grade and HOMA IR.

Discussion

In this study there was no statistical significant association between NAFLD grades and sex of the study population. On the other hand in most studies boys had higher prevalence of NAFLD than girls [27,28]. In a study done by Peng et al. the incidence of NASH in males was significantly higher than in females (14% *vs.* 2.4%), and gender was a risk factor for NASH after adjusting for age, obesity and other components of the metabolic syndrome, and it is similar to results in adults. The reasons for this are not clear so far. It is possible that the fat distribution is more likely to accumulate in the viscera in males, which is more likely to cause metabolic disorders compared with subcutaneous fat, and that estrogen can improve the insulin sensitivity of adipose tissue in females [29].

Also in another study performed on 108 children by Prokopowicz et al. [30], NAFLD was diagnosed more often in boys than in girls however the difference was insignificant (55.1% *vs.* 44.9%), however in an Italian study, prevalence of NAFLD was equal in both sexes [31]. Also, in this study there was no statistical significant association between NAFLD grades and age of the study population, which is similar to results of Peng et al. which documented that there was no significant difference in age among the three groups of NAFLD (simple obesity group, simple steatosis and NASH) [29].

In this study there was no statistical significant association between NAFLD grades and wt., Ht. or BMI of the study population. On the other hand Petrović et al. proved that there were statistically significant differences between groups with different US grades for BMI, and Body Weight (BW). By comparing the groups with different US grades, patients from the NAFLD group with grade 2 US finding had BMI values significantly higher in reference to those from the group with grade 1 US finding. Also, the patients with grade 3 US finding, in comparison with grade 1, had statistically significantly higher BMI. Body weight mean value was the highest in the patients with grade 3 US finding, and statistically significantly higher in patients with grade 2 and then patients with grade 1 [32].

Also, Lee et al. stated in their study that anthropometric measurements including height, weight and BMI increased significantly with hepatic steatosis severity, with higher values seen in the group with more sever disease [33]. The current study shows correlation between WHR and WHtR and fasting glucose, fasting insulin and HOMA IR. There was a statistically significant positive correlation between WHR and WHtR with fasting insulin with p-value <0.001. Also there was highly statistical significant positive correlation between WHR and WHtR with HOMA IR, with p-value <0.001 and this was also shown by Răcătăianu et al. His study reported a statistically significant positive correlation between WHR, WHtR with HOMA IR, and HOMA-IR increased significantly with obesity grade, and with abdominal fat distribution (e.g. BMI, WHR, WHtR) [34].

In this study, there was a highly statistically significant association between NAFLD grades and WHR of the study population. Children with Grade 2 NAFLD showed higher WHR than those with Grade 1 NAFLD. These results are similar to Lee et al., study, in which children with mild NAFLD, their WHR mean ± SD is 0.88 ± 0.05 and those with moderate to severe NAFLD their WHR was 0.94 ± 0.05 [33]. Also, there was a highly statistically significant association between NAFLD grades and WHtR of our study population. Higher WHtR was found in children with Grade 2 NAFLD than in children with grade 1 NAFLD. Again this comes in agreement with another study, in which WHtR mean ± SD in children with mild NAFLD (0.57 ± 0.04) and (0.59 ± 0.05) in children with moderate to severe NAFLD [33].

On the other hand Song et al., stated some different results. He reported that, his study discovered fair correlation between Waist-to-Height Ratio (WHtR) and body mass index (BMI) z-score with Controlled Attenuation Parameter (CAP) values, which indicate hepatic fat deposition, even in the normal range of these parameters [35]. The current study showed no statistically significant association between NAFLD grades and body composition as regards fat mass and body fat analysis.

Opposite to these results, was the results of the study done by Peng et al. in this study body fat in the NASH group was significantly higher than in the Simple Steatosis (SS) and Simple Obesity (SOB) groups. Percentage of body fat in the SS and NASH groups were significantly higher than in the SOB group, but there was no significant difference between the first two groups, indicating that these two anthropometric measurements could not well distinguish the spectrum of NAFLD [29].

However the study done by Prokopowicz et al., showed similar results to the current study results, as Fat mass mean ± SD (36.61 ± 11.58) in patients with NAFLD and (33.44 ± 10.91) in patients without NAFLD with p-value 0.214 and body fat analysis is (39.40 ± 6.34) in patients with NAFLD and (39.15 ± 7.23) in patients without NAFLD with p value 0.897. But he stated that his groups different only in fat free mass and total body water (30). Obesity indicators such as BMI and Body fat in the NASH group were significantly higher than in the simple steatosis and simple obesity groups [29].

This study showed statistically significant association detected between NAFLD grades and fasting insulin level. All children with grade 2 steatosis had abnormal fasting insulin level, while among those with grade 1, 40% had abnormal level and 60% had normal values, similar results were documented in other studies on comparing fasting insulin level in different grades of NAFLD and they found significant difference between different grades as fasting insulin level of children with simple steatosis was 15.01 (14.39) and 21.30 (7.60) in children with NASH [29], similar results were documented by Amin et al., in his study when comparing fasting insulin level in different grades of NAFLD and he found significant difference in different grades [36].

Also this study showed highly statistically significant association between NAFLD grade and HOMA IR where all children with grade 2 NAFLD showed sever IR. Regarding those with Grade 1 7 had no IR (46.7%), 7 had moderate IR (46.7%) and 1 had sever IR (6.7%). This was reported in another study, in which NAFLD was significantly more diagnosed in patients with HOMA-IR exceeding reference values than in children with the normal range of HOMA-IR (79% *vs.* 28%, for HOMA-IR>90 percentile; 85% *vs.* 15%, for HOMA-IR >97%) [37]. In another study done by Torun et al., the HOMA-IR values of children with grade 2-3 NAFLD were significantly higher than those of the control group ($p<0.001$), the obese group without steatosis and the obese group with grade 1 hepatic steatosis ($p<0.05$). Median HOMA-IR significantly increased as the degree of steatosis increased [38]. Insulin resistance was statistically more present in patients with US finding grades 2 and 3 ($p<0.01$) in relation to grade 1 US finding [39,40].

Regarding fasting glucose level, although its Level was in the pre-diabetic range in 4 children with grade 2 NAFLD (80%) and was normal in 1 child (20%), and it was in the pre-diabetic range in 7 children (46.7%) with Grade 1 and normal in 8 children (53.3%). The association was non-significant with p-value >0.05 which is similar to another study done by Lee et al., they stated that fasting glucose level did not differ among the three groups of NAFLD grades which are (normal–mild–sever) [33].

Conclusion

The correlation between NAFLD and IR shown in this study proves that Insulin resistance remains the most important factor affecting progression of liver disease. WHtR is a simple screening tool and an important criterion for the detection of NAFLD. As, Non-Alcoholic Fatty Liver Disease (NAFLD) is the leading cause of paediatric chronic liver disease, it is important to detect early steatosis by WHtR and measuring HOMA-IR.

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