

Anthropometric indices associated with dyslipidemia in obese children and adolescents: a retrospective study in isfahan

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**Abstract**

**BACKGROUND:** Central obesity is an important risk factor for cardiovascular diseases (CVD). Preventive interventions from childhood are necessary due to the increasing prevalence of childhood obesity. Body mass index (BMI), waist circumference (WC), waist to hip ratio (WHR) and waist to height ratio (WSR) are anthropometric indices for measurement of obesity. This study aimed to assess the association between these anthropometric indices and dyslipidemia in obese children and adolescents.

**METHODS:** This retrospective study was done on the records of 2064 obese children and adolescents aged 6-18 years at the obesity clinic, in Isfahan Cardiovascular Research center. Age, gender, weight, height, WC, hip circumference (HC), triglyceride (TG), total cholesterol (TC), LDL-cholesterol (LDL-C), HDL-cholesterol (HDL-C), Fasting blood sugar (FBS), diastolic blood pressure (DBP) and systolic blood pressure (SBP) were taken from patients' record. Receiver operating characteristics (ROC) curve and Pearson correlation were used to analyze the data.

**RESULTS:** 2064 girls and boys aged 6-18 years were divided into 3 age groups of 6-9.9 years, 10-13.9 years and 14-18 years. Prevalence of high LDL-C, TC, TG, FBS, SBP, DBP and low HDL-C was higher among the boys compared to the girls. There was a significant association between TC, LDL-C, TG and FBS with BMI, WC, WHR and WSR. However, no significant correlation was seen between HDL-C and the four anthropometric indices.

**CONCLUSION:** Our study showed a significant correlation between BMI, WC and WSR with high levels of TC, TG and LDL-C in children and adolescents. Correlation between WHR and dyslipidemia in this study was significant but its predictive value was weaker than other three indices.

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**Keywords:** Body Mass Index, Waist Circumference, Waist to Hip Ratio, Waist to Height Ratio, Dyslipidemia, Children, Adolescents.

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**Introduction**

Several risk factors have been identified for cardiovascular diseases (CVD). The most important of which are dyslipidemia, hypertension, diabetes, smoking, sedentary lifestyle and obesity. Among the above risk factors, lipids have been widely investigated due to their extensive association with atherogenesis and atheroma plaque formation inside the arteries as well as vessel stenosis. That is the reason that hyperlipidemia has been introduced as an important risk factor for atherosclerosis and cardiovascular diseases.<sup>1,2</sup> One of the proven risk factors for cardiovascular disease and diabetes is body

visceral fat which is significantly associated with body lipids and lipoproteins.<sup>1-4</sup>

Today, interest and attention to CVD risk factors in children is increasing; because it was well proved that behavioral and biological risk factors of these diseases would happen from the childhood<sup>3,4</sup> and the risk factors such as obesity, dyslipidemia and hypertension would be existed from childhood to adulthood.<sup>5,6</sup>

One of the most important aspects of children's health care is prevention. One of the disease prevention dimensions which recently has been taken into consideration very much is to improve health at

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this age in order to primarily prevent chronic and non-communicable diseases in adulthood.<sup>7</sup>

The increasing prevalence rate of obesity in childhood makes it necessary to identify children at risk for implementing preventive interventions.<sup>3</sup> Overweight in children and adolescents is defined as body mass index (BMI) and the values more than 95 percentile for age and sex are defined obese.<sup>7</sup> Dyslipidemia in children and adolescents is also defined as total cholesterol level, LDL-C and/or triglycerides (TG) higher than 95 percentile or HDL-C lower than 5 percentile for the age and sex.<sup>7</sup> Other important anthropometric indices are waist circumference (WC), hip circumference (HC), waist to hip ratio (WHR) and waist to height ratio (WSR).

Community-based studies have shown that there was an association between anthropometric indices and risk factors of CVD and in children similar to adults, abdominal or upper half fat would increase risk of complications such as dyslipidemia, high blood glucose and hypertension.<sup>8,9</sup> In adults, WC is well associated with abdominal fat and is known as an independent risk factor for obesity-related diseases.<sup>10-12</sup> The results of some studies showed the association of abdominal obesity with high LDL-C low HDL-C and hypertriglyceridemia in adults and children.<sup>13-17</sup> Increase in visceral fat is associated with increase in secretion of free fatty acids, hyperinsulinemia, insulin resistance, hypertension and dyslipidemia.<sup>18,19</sup> Results of other studies also indicated that children with central obesity are more at the risk of many other CVD risk factors.<sup>2,15</sup>

BMI is notable to identify fat from muscle mass and also fat accumulation.<sup>8</sup> World Health Organization recommended WC or WHR to measure abdominal fat distribution.<sup>20</sup> WC is a very sensitive and special indicator of fat in the body upper half.<sup>21</sup> Moreover, WC has less error measurement and when it is measured with the least cloths, it would be of high accuracy.<sup>22</sup> There are some studies supporting WHR in comparison with BMI<sup>18,19</sup> and WC<sup>23-29</sup> to predict CVD. However, some studies underscored WC as the best predictor<sup>26</sup> or showed weak correlation of WHR with all CVD risk factors.<sup>2</sup> Since WHR is the most common used index for distribution of central adipose tissue, its application can be beneficial in measuring those with overweight who may be at the risk of coronary artery disease. In addition, regional adipose distribution was shown to be much more associated with CVD risk than BMI.<sup>24</sup>

Obtaining information through anthropometric indices associated with cardiovascular risk factors in children and adolescents not only is a useful tool for studying obese children, but also shows that how

accumulation of abdominal fat is associated with adults' chronic diseases.<sup>30</sup> Studies showed that measuring body fat of obese children and adolescents can help in finding the people who are prone to CVD in adulthood.<sup>31</sup>

Similar to developed countries, rapid changes in lifestyle has made Iranian children and adolescents prone to CVD risk factors and consequently chronic diseases like CVDs in the future.<sup>7</sup> in a national study in 2004, 11% of the children and adolescents aged 6-18 years in Iran were over weighted and 3.4% had obesity.<sup>16</sup>

Since measuring BMI, WC, WHR and WSR are simple, cost effective and accurate indices to assess body fat distribution, body fat mass and obesity<sup>32</sup> and the association between anthropometric indices and CVD risk factors in children and adolescents was shown in previous studies, it was decided to investigate the association of anthropometric indices with dyslipidemia in children and adolescents through a retrospective study.

## Materials and Methods

This was a retrospective study which was conducted in Isfahan Cardiovascular Research Center in spring 2008. Records of 2064 children and adolescents aged 6-18 years who referred to Childhood Obesity Clinic were investigated. The inclusion criteria included age between 6 to 18 years old and having overweight or obesity. Overweight was defined as BMI between 85 and 95 percentile for the age and sex and obesity as BMI higher than 95 percentile for the age and sex. Incompleteness of the records was the exclusion criteria.

This study was approved by Ethics Committee of Isfahan University of Medical Sciences. Written permission letter had already been received from the parents of the children for conducting required measurements and tests. Age, gender, height, weight, WC, HC, systolic and diastolic blood pressure, fasting blood glucose and lipid profiles (including TC, LDL-C, HDL-C and TG) were extracted from the records of all individuals by a data research expert. Height had been measured and recorded by an associated nurse project with a plastic meter with accuracy of  $\pm 0.2$  cm with bare feet and standing position. Weight of all the study subjects also had been measured with the minimum clothing and with accuracy of  $\pm 0.2$  Kg using a calibrated weight (Seca). WC had been measured at midpoint between lower border of the rib cage and iliac crest at the end of a normal expiration. HC had been measured at the widest part of the hip at the greater trochanter to the nearest 0.5 cm. considering

that all the measurements were done by one nurse and under the observation of a pediatrician, measurement error had diminished.

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured by a physician using a mercury barometer after 5 minutes of resting in sitting position. Cuff width of the barometer was in 40% in medium arm area and covered 80 to 100% of the circumference and two third of the arm's length. At the time of measuring blood pressure, the study subjects were in a position so that the heart, barometer's cuff and manometer zero point were at the same level. Blood pressure was measured three times from right hand. The first BP was measured but not recorded. Thereafter, their blood pressure was measured two more times and the first and fifth sounds of Korotkoff respectively were considered as SBP and DBP.

Fasting blood glucose (FBG), TC, LDL-C, HDL-C and TG were measured through blood samples after 12 hours of fasting in the laboratory of Isfahan Cardiovascular Research Center. FBG, TC, TG and HDL-C were measured using enzyme method by an auto-analyzer. LDL-C was measured using Friedewald formula. BMI was measured using weigh (kg) divided by height square (cm). WHR was measured by dividing waist circumference by hip circumference and WSR by dividing height by waist.

The data was analyzed using Software SPSS16. Pearson correlation and Receiver Operator Characteristic (ROC) test were used. P-values less than 0.05 were considered as significant. The analysis of ROC test was used to calculate area under curve (AUC) of ROC curve. ROC diagram was used to identify the anthropometric cut-off value to determine abnormal level for blood glucose and lipids. AUC was an indicator of power of anthropometric indices to diagnose the outcome of a positive test. AUC of 0 value indicated that anthropometric index had no predictive power but 1 indicated perfect predictive power.

## Results

Table 1 shows average values of anthropometric indices as well as lipid profile, blood pressure and FBS of participants in three age groups of 6-9.9, 10-13.9 and 14-18 years. This table shows that mean of BMI, WC, HC, DBP, LDL-C, HDL-C, TC, TG, FBS, WHR, WSR and SBP of boys were higher than girls and HDL-C reduced with increase in age of the both gender.

Table 2 shows prevalence of CVD risk factors based on sex and age groups. This table shows that prevalence of high values of TC, LDL-C, TG, FBS, SBP and DBP in boys was more than girls and prevalence of low HDL-C was more in boys than girls. Table 3 indicates the association of anthropometric

indices with blood glucose and lipid profile in both groups of boys and girls. Generally in boys, BMI, WC, WHR and WSR increase were significantly correlated with increase in FBS, TC, LDL-C and TG. However, there was no significant correlation between anthropometric indices and HDL-C in boys. Accordingly, increase in BMI, WC, WHR and WSR were significantly correlated with increase in FBS, TC, LDL-C, HDL-C and TG in girls. There was a significant correlation between LDL-C, HDL-C, FBS, TG, TC with BMI, WC, WHR and WSR; however no significant correlation was seen between HDL-C with the four anthropometric indices.

According to ROC diagrams, the highest AUC (area under curve) for the boys was seen in age group 10-14 years; there was also a significant correlation between BMI, WSR and WC in boys' age group 10-14 with FBS. Moreover, these diagrams showed that in boys, the most significant association was between BMI with LDL-C and TC and also between WC and TC in addition to WSR and TC and LDL-C in the age group of 10-14 years. Based on ROC diagrams, the most AUC for girls was between WSR, BMI and WC with TG in 10-14 years age group. In the age groups of 6-9.1 years, there was a significant correlation between WC and TG and in the age group of 14-18 years there was a significant correlation between WSR and LDL.

According to ROC curve analysis, the best cut-off point of BMI to detect high FBS was 26.66 (sensitivity = 0.50 and specificity = 0.74) in 10-14 year-old boys. The corresponding cut-off of BMI to detect TC, LDL-C in 10-14 year-old boys and TG in 6-10 year-old girls was 22.74 (sensitivity = 0.94 and specificity = 0.30), 26.72 (sensitivity = 0.56 and specificity = 0.68) and 19.65 (sensitivity = 0.87 and specificity = 0.28), respectively. In terms of cut-off value of WC for FBS and TC in 10-14 year-old boys, 81.5 (sensitivity = 0.82 and specificity = 0.46), 85.5 (sensitivity = 0.53 and specificity = 0.62) were determined as well as 85.5 (sensitivity = 0.56 and specificity = 0.72) and 81.5 (sensitivity = 0.53 and specificity = 0.60) for FBS and TG in 10-14 year-old girls. In 6-10 year-old girls, WC cut-off to detect high TG was 72.5 (sensitivity = 0.57 and specificity = 0.58). The cut-off value of WSR in 10-14 year-old boys was detected as 0.56 (sensitivity = 0.79 and specificity = 0.53) for high FBS. In terms of high TC and LDL in 10-14 year-old boys, 0.56 (sensitivity = 0.70 and specificity = 0.50) and 0.60 (sensitivity = 0.38 and specificity = 0.78) as well as 0.54 (sensitivity = 0.68 and specificity = 0.51) for TG in girls of the same age group were found for WSR. In 14-18 year-old girls WSR cut-off was 0.58 (sensitivity = 0.63 and specificity = 0.68) to detect high LDL-C.

**Table 1.** Mean age, anthropometric indices, lipid profiles, fasting blood glucose and blood pressure in the study subjects based on sex and age group, mean (standard deviation)

|                     | 6-9.9 year                  | 10-13.9 year                | 14-18 year                 | Total                       |
|---------------------|-----------------------------|-----------------------------|----------------------------|-----------------------------|
| <b>Boys Number</b>  | <b>390</b>                  | <b>445</b>                  | <b>94</b>                  | <b>929</b>                  |
| Age                 | 7.86 (1.08)                 | 11.30 (1.08)                | 14.85 (0.94)               | 10.22 (2.49)*               |
| BMI                 | 23.08 (3.92)                | 25.65 (3.97)                | 29.05 (4.25)               | 24.92 (4.38)*               |
| WC                  | 76.33 (8.28)                | 85.14 (10.43)               | 95.06 (11.45)              | 82.45 (11.38)*              |
| HC                  | 83.53 (7.79)                | 93.24 (10.83)               | 102.90 (11.29)             | 90.14 (11.58)*              |
| WHR                 | 0.91 (0.06)                 | 0.92 (0.06)                 | 0.93 (0.07)                | 0.92 (0.06)                 |
| WSR                 | 0.58 (0.06)                 | 0.57 (0.06)                 | 0.59 (0.06)                | 0.58 (0.06)                 |
| SBP                 | 105.49 (13.43)              | 109.76 (13.16)              | 114.69 (13.34)             | 108.45 (13.61)*             |
| DBP                 | 63.66 (8.68)                | 66.68 (9.82)                | 68.01 (9.50)               | 65.92 (9.44)*               |
| LDL-C               | 112.52 (31.53)              | 116.55 (33.04)              | 115.07 (30.38)             | 114.72 (32.17)              |
| HDL-C               | 47.50 (12.71)               | 45.35 (10.94)               | 42.27 (11.69)              | 45.93 (11.87)*              |
| TC                  | 183.13 (32.47)              | 188.89 (34.91)              | 186.98 (34.48)             | 186.30 (33.94)              |
| TG                  | 115.36 (65.33)              | 133.86 (72.83)              | 155.04 (84.94)             | 128.35 (72.22)*             |
| FBS                 | 89.20 (10.43)               | 89.10 (12.19)               | 94.98 (36.16)              | 89.77 (16.04)*              |
| <b>Girls Number</b> | <b>545</b>                  | <b>467</b>                  | <b>123</b>                 | <b>1135</b>                 |
| Age                 | 7.77 (1.07)                 | 11.16 (1.07)                | 15.15 (1.25)               | 9.97 (2.65)*                |
| BMI                 | 21.90 (2.88)                | 25.06 (3.38)                | 28.93 (3.69)               | 23.96 (3.92)*               |
| WC                  | 73.20 (8.51)                | 81.97 (9.78)                | 87.94 (11.06)              | 78.24 (10.74)*              |
| HC                  | 81.59 (8.37)                | 90.88 (10.82)               | 100.72 (11.63)             | 87.31 (11.68)*              |
| WHR                 | 0.90 (0.06)                 | 0.90 (0.06)                 | 0.88 (0.07)                | 0.90 (0.06)*                |
| WSR                 | 0.55 (0.06)                 | 0.056 (0.06)                | 0.57 (0.06)                | 0.56 (0.06)                 |
| SBP                 | 102.78 (13.72)              | 110.65 (11.99)              | 113.11 (12.11)             | 107.39 (13.48)*             |
| DBP                 | 63.01 (9.79)                | 66.86 (8.94)                | 67.76 (8.76)               | 65.23 (9.52)*               |
| LDL-C               | 110.92 (29.99)              | 111.50 (32.77)              | 113.54 (33.09)             | 111.44 (31.44)              |
| HDL-C               | 46.21 (12.06)               | 44.07 (11.18)               | 43.19 (9.66)               | 45.02 (11.52)*              |
| TC                  | 181.84 (32.80)              | 183.81 (35.99)              | 182.84 (39.54)             | 182.76 (34.91)              |
| TG                  | 114.22 (50.37)              | 137.65 (68.35)              | 142.55 (88.32)             | 126.96 (64.31)*             |
| FBS                 | 87.30 (11.79)               | 88.56 (10.84)               | 86.53 (9.88)               | 87.72 (11.24)               |
| <b>Total Number</b> | <b>935</b>                  | <b>912</b>                  | <b>217</b>                 | <b>2064</b>                 |
| Age                 | 7.81 (1.07) <sup>¶</sup>    | 11.23 (1.08)                | 15.02 (1.13) <sup>¶</sup>  | 10.08 (2.58) <sup>*¶</sup>  |
| BMI                 | 22.39 (3.40) <sup>¶</sup>   | 25.35 (3.69) <sup>¶</sup>   | 28.98 (3.93)               | 24.39 (4.16) <sup>*¶</sup>  |
| WC                  | 74.52 (8.55) <sup>¶</sup>   | 83.60 (10.23) <sup>¶</sup>  | 91.13 (11.75) <sup>¶</sup> | 80.19 (11.24) <sup>*¶</sup> |
| HC                  | 82.41 (8.18) <sup>¶</sup>   | 92.10 (10.88) <sup>¶</sup>  | 101.70 (11.49)             | 88.62 (11.72) <sup>*¶</sup> |
| WHR                 | 0.90 (0.06) <sup>¶</sup>    | 0.91 (0.06) <sup>¶</sup>    | 0.90 (0.08) <sup>¶</sup>   | 0.91 (0.06) <sup>¶</sup>    |
| WSR                 | 0.56 (0.06) <sup>¶</sup>    | 0.57 (0.06) <sup>¶</sup>    | 0.58 (0.06) <sup>¶</sup>   | 0.57 (0.06) <sup>¶</sup>    |
| SBP                 | 103.99 (13.65) <sup>¶</sup> | 110.23 (12.55)              | 113.81 (12.65)             | 107.88 (13.55)*             |
| DBP                 | 63.30 (9.30)                | 66.77 (9.36)                | 67.87 (9.06)               | 65.36 (9.48)*               |
| LDL-C               | 111.57 (30.61)              | 114.00 (32.98) <sup>¶</sup> | 114.19 (31.89)             | 112.91 (31.80) <sup>¶</sup> |
| HDL-C               | 46.73 (12.33)               | 44.70 (11.07)               | 42.80 (10.56)              | 45.43 (44.68)*              |
| TC                  | 182.38 (32.65)              | 186.30 (35.54) <sup>¶</sup> | 184.63 (37.40)             | 184.35 (34.51) <sup>¶</sup> |
| TG                  | 114.69 (57.01)              | 135.80 (70.55)              | 147.96 (86.89)             | 127.59 (67.96)*             |
| FBS                 | 88.09 (11.28) <sup>¶</sup>  | 88.83 (11.52)               | 90.43 (25.89) <sup>¶</sup> | 88.66 (13.68) <sup>¶</sup>  |

\* P < 0.05 between age group, P < 0.05 between sexes, BMI: Body mass index, WC: Waist circumference, HC: Height circumference, WHR: Waist hip ratio, WSR: Waist to height ratio, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, TC: Total cholesterol, TG: Triglyceride, FBS: Fasting blood sugar

**Table 2.** Prevalence rate of different CVD risk factors based on sex and age groups

|   | Boys (n =929 )    | Girls (n =1135 )  | Total (n = 2064)  |
|---|-------------------|-------------------|-------------------|
| <b>Prevalence (%) of high TC</b>        |                   |                   |                   |
| 6-9.9 years                             | 41.8              | 31.2              | 35.6*             |
| 10-13.9 years                           | 32.2              | 26.3              | 29.2              |
| 14-18 years                             | 42.9              | 23.5              | 31.9*             |
| Total                                   | 37.3 <sup>¶</sup> | 28.4              | 32.4 <sup>¶</sup> |
| <b>Prevalence (%) of high LDL-C</b>     |                   |                   |                   |
| 6-9.9 years                             | 27.2              | 15.7              | 20.3*             |
| 10-13.9 years                           | 29.2              | 21.4              | 25.2*             |
| 14-18 years                             | 32.9              | 20.4              | 25.7              |
| Total                                   | 28.7              | 18.4              | 23*               |
| <b>Prevalence (%) of high HDL-C</b>     |                   |                   |                   |
| 6-9.9 years                             | 22.9              | 20.3              | 21.3              |
| 10-13.9 years                           | 25.1              | 30.2              | 27.7              |
| 14-18 years                             | 15.6              | 30.4              | 24.0*             |
| Total                                   | 23.2              | 25.4 <sup>¶</sup> | 24.4 <sup>¶</sup> |
| <b>Prevalence (%) of high TG</b>        |                   |                   |                   |
| 6-9.9 years                             | 60.8              | 34                | 45.1*             |
| 10-13.9 years                           | 56.5              | 53.7              | 55                |
| 14-18 years                             | 52.2              | 47.5              | 49.5              |
| Total                                   | 57.8              | 43.5 <sup>¶</sup> | 49.9 <sup>¶</sup> |
| <b>Prevalence (%) of high FBS</b>       |                   |                   |                   |
| 6-9.9 years                             | 13.1              | 9.3               | 10.9              |
| 10-13.9 years                           | 14.1              | 12.9              | 13.5              |
| 14-18 years                             | 21.3              | 7.5               | 13.9*             |
| Total                                   | 14.4              | 10.6              | 12.3*             |
| <b>Prevalence (%) of high SBP/DBP</b>   |                   |                   |                   |
| 6-9.9 years                             | 0.4               | 0.3               | 0.4               |
| 10-13.9 years                           | 3                 | 1.4               | 2.2               |
| 14-18 years                             | 1.6               | 5                 | 3.5               |
| Total                                   | 1.7               | 1.3 <sup>¶</sup>  | 1.5               |
| <b>Prevalence (%) of hyperlipidemia</b> |                   |                   |                   |
| 6-9.9 years                             | 77                | 60.9              | 67.5*             |
| 10-13.9 years                           | 73.8              | 71.1              | 72.4              |
| 14-18 years                             | 75.8              | 64.7              | 69.5              |
| Total                                   | 75.3              | 65.5 <sup>¶</sup> | 69.9*             |

P < 0.05 between age group, \* P < 0.05 between sexes, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, TC: Total cholesterol, TG: Triglyceride, FBS: Fasting blood sugar

**Table 3.** The changes in components of metabolic syndrome in all of the study subjects

|       |       | 6-9.9 year |        |        |        | 10-13.9 year |         |        |         | 14- 18 year |       |        |        | Total   |        |       |        |
|-------|-------|------------|--------|--------|--------|--------------|---------|--------|---------|-------------|-------|--------|--------|---------|--------|-------|--------|
|       |       | BMI        | WC     | WHR    | WSR    | BMI          | WC      | WHR    | WSR     | BMI         | WC    | WHR    | WSR    | BMI     | WC     | WHR   | WSR    |
| Boys  | FBS   | -0.02      | 0.127* | 0.069  | 0.052  | 0.167**      | 0.179** | -0.012 | 0.166** | 0.153       | 0.114 | 0.000  | 0.024  | 0.12**  | 0.16** | 0.016 | 0.08   |
|       | TC    | 0.048      | 0.06   | 0.035  | 0.054  | 0.237**      | 0.165** | 0.128* | 0.231** | 0.043       | 0.021 | 0.16   | -0.003 | 0.15**  | 0.12** | 0.09* | 0.13** |
|       | LDL-C | -0.004     | -0.029 | -0.001 | -0.001 | 0.258**      | 0.139** | 0.103  | 0.209** | -0.11       | -0.16 | -0.121 | -0.167 | 0.12**  | 0.054  | 0.04  | 0.08   |
|       | HDL-C | -0.07      | 0.07   | 0.048  | 0.03   | -0.017       | 0.004   | -0.034 | 0.023   | 0.019       | -0.11 | 0.16   | -0.126 | -0.09   | -0.062 | 0.02  | 0.01   |
|       | TG    | 0.065      | -0.002 | -0.035 | -0.064 | 0.053        | 0.126*  | 0.026  | 0.107   | 0.135       | 0.074 | -0.183 | 0.014  | 0.13**  | 0.18** | -0.02 | 0.03   |
| Girls | FBS   | 0.086      | 0.075  | -0.024 | 0.05   | 0.093        | 0.16*   | 0.012  | 0.084   | 0.11        | 0.19  | 0.197  | 0.229  | 0.08*   | 0.10** | 0.023 | 0.07   |
|       | TC    | 0.017      | -0.007 | 0.047  | 0.026  | 0.039        | 0.034   | -0.014 | 0.107   | 0.119       | 0.09  | 0.184  | 0.275* | 0.04    | 0.015  | 0.05  | 0.09*  |
|       | LDL-C | 0.019      | -0.055 | 0.066  | -0.002 | 0.017        | -0.053  | 0.071  | 0.044   | 0.116       | 0.109 | 0.254* | 0.259* | 0.04    | -0.027 | 0.10* | 0.05   |
|       | HDL-C | -0.09*     | -0.023 | -0.083 | -0.021 | -0.017       | -0.056  | -0.063 | 0.017   | -0.01       | -0.18 | 0.051  | -0.078 | -0.10** | -0.09* | -0.05 | -0.017 |
|       | TG    | 0.10*      | 0.136* | 0.066  | 0.071  | 0.014        | 0.142*  | 0.065  | 0.166*  | 0.014       | 0.062 | 0.05   | 0.162  | 0.14**  | 0.20** | 0.058 | 0.13** |
| Total | FBS   | 0.05       | 0.11** | 0.027  | 0.05   | 0.14**       | 0.17**  | 0.001  | 0.13**  | 0.13        | 0.15  | 0.087  | 0.079  |         |        |       |        |
|       | TC    | 0.035      | 0.027  | 0.046  | 0.045  | 0.15**       | 0.11**  | 0.066  | 0.18**  | 0.08        | 0.097 | 0.21** | 0.17*  |         |        |       |        |
|       | LDL-C | 0.012      | -0.037 | 0.038  | 0.005  | 0.15**       | 0.058   | 0.09*  | 0.14**  | 0.017       | 0.019 | 0.135  | 0.09   |         |        |       |        |
|       | HDL-C | -0.07      | 0.023  | -0.017 | 0.012  | -0.014       | -0.022  | -0.045 | 0.023   | 0.007       | -0.15 | 0.087  | -0.11  |         |        |       |        |
|       | TG    | 0.08*      | 0.063  | 0.009  | -0.005 | 0.033        | 0.13**  | 0.042  | 0.13**  | 0.069       | 0.09  | -0.023 | 0.10   |         |        |       |        |

BMI: Body mass index, WC: Waist circumference, HC: Height circumference, WHR: Waist hip ratio, WSR: Waist to height ratio, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, TC: Total cholesterol, TG: Triglyceride, FBS: Fasting blood sugar

## Discussion

In spite of some previous studies, the results of the present study showed that merely one anthropometric indicator (out of four) cannot be introduced as the best predictor for CVD risk factors. In this study, better anthropometric index for predicting dyslipidemia in children and adolescents was different based on age groups and gender. Among the boys in the age group 10-14 years, WSR, BMI and WC had the highest predictive value for high TC and LDL-C. In general, WSR, BMI and WC had the higher predictive value for LDL-C, TC and TG in boys. In the boys of the present study, there was no significant correlation between HDL-C with anthropometric indices. In the girls aged 10-14 years, the highest predictive value of high TG was associated with BMI, WSR and WC. Girls aged 6-10 years had the highest predictive value of high TG, which was WC and in 14-18 years group highest predictive value of high LDL-C was WSR. Finally, the present study showed that WC, BMI and WSR had the most significant correlation with TG, TC, LDL-C in different age groups, but no association was seen between HDL-C and anthropometric indices.

The results of the present study were in accordance with CASPIAN study in Iran in which BMI, WC and WSR were introduced as the best predictors of cardiovascular risk factors in children and adolescents.<sup>3</sup> In a study on adults in Iran, WHR and WC were better indices for predicting dyslipidemia in adults.<sup>23</sup> In both CASPIAN and our study, WC was one of the important indices in predicting dyslipidemia, however, in the present study WSR and BMI also were two other important indices. The difference might be due to the age of the study subjects or sample size. As indicated earlier, World Health Organization recommends WC or WHR to measure abdominal fat distribution.<sup>20</sup> The results of some of the studies showed that BMI cannot differentiate the fat from the muscle mass and also cannot indicate adipose distribution, therefore some researchers believe that BMI is not a good indicator to predict CVD risk factors.<sup>32</sup> In the present study, BMI along with WSR and WC were the best predictors of high TG, TC and LDL-C in children and adolescents; however, no significant correlation was seen between HDL-C and these four indices, while in the study of Sarni et al. there was a significant correlation between HDL-C and anthropometric indices in children.<sup>2</sup> This difference might be due to sample size and also age of the subjects, because in the study of Sarni et al., sample size was only 65 people and the study subjects were pre-school

children.<sup>2</sup> Some studies showed that WHR had a better role as an abdominal fat accumulation index in comparison with BMI for predicting cardiovascular risk factors.<sup>18,19</sup> On the contrary, the result of a study on children showed that WHR had a weak correlation with all the risk factors<sup>2</sup> which the results was closer to the results of the present study; because in the present study WHR - in comparison with BMI, WSR and WC - was also considered as a weaker predictor for dyslipidemia in children and adolescents. Some of the studies have shown that WC, in comparison with WHR, was a better index to assess CVD risk factors<sup>26</sup> and some other studies had introduced WHR as a better index.<sup>27</sup> The present study also indicated that WC, in comparison with WHR, was a better index to assess dyslipidemia in children and adolescents.

The study results of Montanes et al. showed that there was a significant correlation between HDL-C and WC.<sup>28</sup> Such a correlation was found about the girls in the present study, but it was not found in the whole sample. The difference could be due to the difference in sample size. Sample size of Montanes et al. study was 240 but 2064 for this study. Although in the present study, BMI was one of the predictors of dyslipidemia in children and adolescents and had a significant correlation with high LDL-C, TG and TC; but some evidences indicated that regional fat distribution was more obvious than BMI with CVD risk factors.<sup>24</sup>

General result of the present study indicated a significant correlation between BMI, WC and WSR with high levels of LDL-C, TG and TC in children and adolescents aged 6-18 years old. However, in some cases also there was a significant correlation between WHR with dyslipidemia but this correlation was weaker than other three indices of BMI, WC and WSR. In general, the present study did not show any significant correlation between low HDL-C with anthropometric indices except in the girls.

## Conflict of Interests

Authors have no conflict of interests.

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