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Assessment of Obesity and Related Conditions in Middle School Children

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ABSTRACT

Objectives: This study investigated the relationship between obesity and hyperlipidemia, hypertension and blood glucose in secondary school children.

Methods: Children between 12 and 17 years old who applied to the Family Health Centers were included. The body mass index, blood pressure, fasting blood glucose, and lipid levels of the children were retrospectively evaluated. All participants were divided into four groups (underweight, normal, overweight, obese) according to body mass index. In the second stratification, children were examined as two groups (obese, non-obese).

Results: Three hundred seven children 53 (17.4%) of whom were obese participated in the study. The mean systolic blood pressure was 119.6±14.5 mm/Hg in obese children and 113.1±11.7 mm/Hg in non-obese children, while mean diastolic blood pressure was 72.2±9.7 mm/Hg in obese group and 68.3±8.9 mm/Hg in non-obese group ($p=0.001$ and $p=0.005$, respectively). LDL-cholesterol levels were found as 102.0 [32.0] mg/dL in obese group and 89.5 [32.0] mg/dL in non-obese group, triglyceride as 96.0 [50.0] mg/dL in obese group and 76 [43.0] mg/dL in non-obese group, and total cholesterol as 170.0 [35.0] mg/dL in obese group and 155.0 [35.0] mg/dL in non-obese group ($p<0.001$, $p=0.015$ and $p=0.006$, respectively). In correlation analysis, body mass index and systolic blood pressure, diastolic blood pressure, LDL-cholesterol, triglyceride, and total cholesterol levels was significantly positive ($r=0.230$ and $p<0.001$; $r=0.155$ and $p=0.007$; $r=0.139$ and $p=0.015$; $r=0.149$ and $p=0.009$; $r=0.123$ and $p=0.032$, respectively).

Conclusion: In the present study obese children were found to be closely related to dyslipidemia and hypertension.

Keywords: Adolescents, obesity, hypertension, hyperlipidemia



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INTRODUCTION

Obesity is a complex, multifactorial disorder characterized by an increase in body fat ratio and behavioral, endocrine, and metabolic changes. The increasing prevalence of obesity particularly starts from childhood through increased usage of technological tools, decreasing mobility, and alterations in dietary habits among many other reasons. Thus, obesity has become a public health issue in recent years.^[1,2] As obesity in childhood increases, the prevalence of chronic disorders in adults caused by childhood obesity also increases. Consequently, childhood obesity is a predisposing factor for type 2 diabetes mellitus (DM) including insulin resistance, polycystic ovary syndrome, hypertension, hypercholesterolemia, dyslipidemia, cardiovascular disease, sleep apnea, asthma, and nonalcoholic steatohepatitis, orthopedic disorders, and pseudotumor cerebri. DM, cardiovascular disorders, and some cancer types are the most important ones among the diseases caused by obesity. Moreover, atherosclerosis, the most common among the aforementioned disorders, is mainly caused by uncontrolled

hyperlipidemia and high blood pressure. Pediatric obesity is also a predisposing factor for adolescent and adult obesity. Thus, childhood obesity leads to obesity in adults and clinical signs of the aforementioned disorders become more severe.^[1-4]

Triggering factors of obesity occur starting from childhood, and further disorders are encountered in these patients as age increases leading to higher mortality and morbidity.^[1-4] Some studies have been carried out on the etiology of disorders affecting most people of advanced age. However, these studies have included certain populations, and the number of studies including the adolescent age group attending middle school is limited. Moreover, the middle school age group somewhat includes the adolescent population. Consequently, 50% of the children who become obese in adolescence are also expected to be affected by obesity when they become adults and may be exposed to the risks caused by DM and cardiovascular disorders.^[4-8] Furthermore, body mass index (BMI) is weight in kilograms divided by the square of the height of children in meters. It is the gold standard in obesity assessment. BMI may vary based on age and gender in children and adolescents. Usually, it increases starting from the first months after birth, decreases after the first year, and increases once more after 6 years. Thus, age- and gender-adjusted BMI values are assessed by comparing them with reference values and based on percentile curves.^[4,5] In general, a BMI >85th percentile is considered as under risk of being overweight. Children over the 95th percentile are considered overweight and obese and are also in need of intervention.^[4,5]

This study aimed to investigate the relationship between obesity and hyperlipidemia, hypertension, and high fasting blood glucose in secondary school children.

METHOD

This study included secondary school children between 12 and 17 years old who applied to Sancaktepe Hamdi Oral, Ümraniye Hekimbaşı and Durmuş Tanış and 22th Üsküdar Family Health Centers between 1 January 2017 and 1 January 2020 for school screening examination. BMI, blood pressure, fasting blood glucose and lipid levels of the children were retrospectively evaluated by using the database of the family health centers.

Children included in this study were stratified in two ways. According to BMI and percentile values, classified into four groups as underweight ($\leq 5\%$ percentile), normal (6–85% percentile), overweight (86%–94% percentile) and obese ($\geq 95\%$ percentile) and according to general information classified into two groups as obese ($\geq 95\%$ percentile) and non-obese ($< 95\%$ percentile).

Fasting blood glucose, total cholesterol, triglyceride, high-density lipoprotein (HDL) cholesterol, and low-density lipoprotein (LDL) cholesterol levels of children included in the study recorded in the last 6 months in the database of family health centers were examined. All of the biochemical examinations were carried on in the General Directorate of Public Health Laboratory Information System central laboratory. The Lipid profiles and the glucose levels had been analysed by Olympus AU 5223 Analyser (Diagnostic Systems Group of Olympus America, USA) in colorimetric method. LDL-cholesterol levels had been calculated by Friedewald formula (Total cholesterol – (HDL-cholesterol+(Triglyceride /5)). The children whose data are missing were excluded.

All statistical analysis was carried out using the Statistical Package for the Social Sciences software, version 25.0 (IBM SPSS, Chicago, IL, USA). Discrete data were expressed as frequency and percentage. Continuous variables which distributed normally were expressed as mean, standard deviation whereas abnormally distributed variables as median (interquartile range). A comparison between categorical variables was done using Pearson's Chi-square test. The conformity of continuous variables to normal distribution was confirmed by the Kolmogorov Smirnov test and Shapiro-Wilk test. Independent samples t-test and One way ANOVA used for normally distributed continuous variables. Mann-Whitney U test and Kruskal Wallis test were used for comparison of continuous variables with non-normal distribution. The Bonferroni correction was applied for multiple comparisons. Moreover, continuous variables with normal distribution were evaluated with the Pearson correlation test and continuous variables without normal distribution were evaluated with the Spearman correlation analysis. A p value < 0.05 was considered statistically significant.

RESULTS

A total number of 307 children were included in the study and 164 (53.8%) of children were females. Distribution of

Table 1. Distribution of gender according to body mass index groups

| | Male (n=141) | Female (n=164) | Total (n=305) | p |
|-------------|-----------------|-------------------|------------------|-------|
| Underweight | 25 (17.8) | 20 (12.2) | 45 (14.8) | 0.105 |
| Normal | 72 (51.1) | 91 (55.5) | 163 (53.4) | |
| Overweight | 25 (17.7) | 19 (11.6) | 44 (14.4) | |
| Obese | 19 (13.4) | 34 (20.7) | 53 (17.4) | |

Data expressed as n (%).
Pearson's Chi-square test.

gender according to BMI groups is summarized in Table 1.

When blood pressure values were compared according to BMI groups, a significant difference was found between underweight and obese and normal and obese in terms of systolic blood pressure (SBP), SBP percentile and diastolic blood pressure (DBP) ($p=0.012$, $p=0.022$ for SBP; $p=0.006$, $p=0.025$ for SBP percentile; $p=0.020$, $p=0.038$ for DBP respectively). Also, there was significant difference between the underweight and obese in terms of DBP percentile ($p=0.045$). When lipid profile was compared according to BMI groups, a significant difference was found between underweight and obese in terms of HDL-cholesterol, triglyceride and total cholesterol ($p=0.012$, $p=0.022$ and $p=0.026$ respectively). Furthermore, there were significant differences between the underweight and obese and between normal and obese in terms of LDL-cholesterol ($p=0.012$ and $p=0.015$, respectively). Comparison of age, metabolic parameters and blood pressure values according to the BMI groups are summarized in Table 2.

Fifty three (17.4%) of the children were obese and 252 (82.6%) were in the non-obese group. Comparison of age, metabolic parameters and blood pressure values of obese and non-obese patients are summarized in Table 3.

There was no significant difference in gender between the obese and non-obese groups. While SBP, SBP percentile, DBP and DBP percentile were significantly higher in obese women, no significant difference was found in obese men. Comparison of age, metabolic parameters and blood pressure values of obese and non-obese patients according to gender are summarized in Table 4.

The correlation analysis between BMI and blood pres-

Table 3. Comparison of age, metabolic parameters and blood pressure values of obese and non-obese patients

| | Non-obese (n=252) | Obese (n=53) | p |
|-------------------------------|----------------------|-----------------|---------------------|
| Age (year) | 13.6±1.4 | 13.9±1.4 | 0.065* |
| SBP (mm/Hg) | 113.1±11.7 | 119.6±14.5 | 0.001* |
| SBP percentile | 60.2±29.2 | 71.6±30.6 | 0.011* |
| DBP (mm/Hg) | 68.3±8.9 | 72.2±9.7 | 0.005* |
| DBP percentile | 62.4±24.8 | 71.4±26.6 | 0.019* |
| Fasting blood glucose (mg/dl) | 92.9±10.1 | 92.8±8.7 | 0.956* |
| LDL-cholesterol (mg/dl) | 89.5 [32.0] | 102.0 [32.0] | <0.001 [†] |
| HDL-cholesterol (mg/dl) | 48.0 [12.0] | 43.0 [14.0] | 0.184 [†] |
| Triglyceride (mg/dl) | 76.0 [43.0] | 96.0 [50.0] | 0.015 [†] |
| Total cholesterol (mg/dl) | 155.0 [35.0] | 170.0 [35.0] | 0.006 [†] |

DBP: Diastolic blood pressure; HD: High density lipoprotein; LDL: Low density lipoprotein; SBP: Systolic blood pressure.
Data expressed as mean±standard deviation and median[IQR].
*Independent sample t test, [†]Mann-Whitney U test.

sure and metabolic indices of children showed that BMI and SBP and DBP levels were significantly positively correlated ($r=0.230$, $p<0.001$ and $r=0.155$, $p=0.007$, respectively). Moreover, LDL-cholesterol, triglyceride and total cholesterol levels were significantly positively correlated with BMI whereas HDL-cholesterol levels were significantly negatively correlated ($r=0.139$ and $p=0.015$; $r=0.149$ and $p=0.009$; $r=0.123$, $p=0.032$; $r=-0.175$ and $p=0.002$, respectively). However the correlation between BMI and fasting glucose was not found significant ($p=0.857$).

In children stratified into 4 groups according to BMI, the

Table 2. Comparison of age, metabolic parameters and blood pressure values according to the body mass index groups

| | Underweight (n=45) | Normal (n=163) | Overweight (n=44) | Obese (n=53) | Total (n=305) | p |
|-------------------------------|--------------------|----------------|-------------------|--------------|---------------|--------------------|
| Age (year) | 13.9±1.5 | 13.4±1.3 | 13.6±1.4 | 13.9±1.4 | 13.6±1.4 | 0.051* |
| SBP (mm/Hg) | 11.5±10.5 | 113.3±12.2 | 114.0±11.2 | 119.6±14.5 | 114.2±12.5 | 0.009* |
| SBP percentile | 54.4±29.0 | 60.7±29.6 | 64.2±27.2 | 71.6±30.6 | 62.2±29.7 | 0.007* |
| DBP (mm/Hg) | 67.4±6.8 | 68.6±8.9 | 68.2±10.7 | 72.2±9.7 | 69.0±9.1 | 0.017* |
| DBP percentile | 60.1±22.2 | 63.0±25.0 | 62.4±26.4 | 71.4±26.6 | 64.0±25.3 | 0.034* |
| Fasting blood glucose (mg/dl) | 91.1±7.7 | 93.0±11.3 | 94.2±7.3 | 92.8±8.7 | 92.8±9.9 | 0.354* |
| LDL-cholesterol (mg/dl) | 86.0 [30.0] | 94.0 [5.0] | 97.0 [20.0] | 104.0 [22.0] | 96.0 [25.0] | 0.008 [†] |
| HDL-cholesterol (mg/dl) | 48.0 [11.0] | 49.0 [10.0] | 47.0 [10.0] | 45.0 [8.0] | 48.0 [9.0] | 0.023 [†] |
| Triglyceride (mg/dl) | 71.0 [39.0] | 86.0 [42.0] | 89.0 [51.0] | 99.0 [49.0] | 87.0 [43.0] | 0.033 [†] |
| Total cholesterol (mg/dl) | 150.0 [33.0] | 160.0 [32.0] | 160.0 [29.0] | 169.5 [29.5] | 161.0 [32.0] | 0.039 [†] |

DBP: Diastolic blood pressure; HD: High density lipoprotein; LDL: Low density lipoprotein; SBP: Systolic blood pressure.

Data expressed as mean±standard deviation and median[IQR].

*One way ANOVA test, [†]Kruskal –Wallis test and Bonferroni correction.

Table 4. Comparison of age, metabolic parameters and blood pressure values of obese and non-obese patients according to gender

| | Non-obese (n=252) | Obese (n=53) | p |
|-------------------------------|----------------------|-----------------|--------------------|
| Age (years) | | | |
| Male | 13.7±1.4 | 14.1±1.4 | 0.242* |
| Female | 13.4±1.3 | 13.9±1.4 | 0.102* |
| SBP (mm/Hg) | | | |
| Male | 115.0±11.2 | 118.5±17.8 | 0.248* |
| Female | 111.3±12.0 | 120.2±12.6 | <0.001* |
| SBP percentile | | | |
| Male | 62.4±27.9 | 64.4±34.5 | 0.781* |
| Female | 58.1±30.3 | 75.6±28.0 | 0.003* |
| DBP (mm/Hg) | | | |
| Male | 68.2±8.7 | 69.0±10.2 | 0.711* |
| Female | 68.4±9.0 | 74.0±9.0 | 0.002* |
| DBP percentile | | | |
| Male | 62.5±24.8 | 62.2±25.8 | 0.967* |
| Female | 62.4±24.9 | 76.5±25.9 | 0.004* |
| Fasting blood glucose (mg/dl) | | | |
| Male | 95.1±8.5 | 93.1±10.0 | 0.363* |
| Female | 90.8±11.1 | 92.6±8.0 | 0.379* |
| LDL-cholesterol (mg/dl) | | | |
| Male | 88.0 [29.0] | 100.0 [34.0] | 0.007 [†] |
| Female | 92.5 [33.5] | 103.0 [32.0] | 0.297 [†] |
| HDL-cholesterol (mg/dl) | | | |
| Male | 46.0 [29.0] | 40.0 [12.0] | 0.148 [†] |
| Female | 50.0 [13.0] | 46.0 [12.0] | 0.135 [†] |
| Triglyceride (mg/dl) | | | |
| Male | 76.0 [43.0] | 99.0 [78.0] | 0.114 [†] |
| Female | 75.0 [44.0] | 96.0 [51.0] | 0.070 [†] |
| Total cholesterol (mg/dl) | | | |
| Male | 150.0 [35.0] | 172.0 [30.0] | 0.010 [†] |
| Female | 162.1 [38.0] | 168.5 [36.5] | 0.178 [†] |

DBP: Diastolic blood pressure; HD: High density lipoprotein; LDL: Low density lipoprotein; SBP: Systolic blood pressure.
Data expressed as mean±standard deviation and median [IQR].
*Independent sample t test, [†]Mann Whitney U test.

number of both systolic and diastolic hypertensive patients was significantly more in the obese group compared with the other groups. While 12 (22.6%) of the 53 obese children were found hypertensive regarding SBP this ratio was 11 (4.3%) of the 252 non-obese children ($p=0.001$). As for diastolic blood pressure, 9 (16.9%) of the obese group and 16 (6.3%) of the non-obese children group were found hypertensive ($p=0.005$).

DISCUSSION

This study aimed to investigate the relationship between obesity and hyperlipidemia, hypertension, and fasting blood glucose level in secondary school children. In this age group, obesity prevalence was found as 17.4%. Childhood obesity which was reported to be approximately 10% in the 1980s was reported to increase by approximately 20% in recent years.^[9] Currently, 25% and 10% of children, particularly in developed countries, are overweight and obese, respectively. Thus, obesity is becoming a public health issue in developing countries as well.^[10] It is reported that 86% of those 13–19 years old obese adolescents stay obese when they become young adults.^[6] Moreover, the triggering factors of obesity that occur starting from childhood lead to further disorders in adulthood and mortality with higher morbidity in these adult patients because obesity occurring at childhood give rise to more severe clinical results in several disorders by increasing age.^[1-3]

Uncontrolled high blood lipid levels and high blood pressure that leads to cardiovascular disorders are among the most important disease caused by obesity. Some studies have been done to find out the etiology of these disorders affecting most of the population in advanced age. However, these studies have included certain populations, and the number of studies including the adolescent age group attending middle school is limited. However, the middle school age group somewhat includes the adolescent population. Consequently, 50% of the children who are obese in adolescence are also expected to be affected by obesity when they become adults and may be exposed to the risks created by DM and cardiovascular disorders.^[3,7,11]

Obesity occurs as a result of uncontrolled diet in childhood, and multiple risk factors of obesity exist.^[8] Furthermore, obesity may develop in children due to factors other than diet. Various metabolic disorders may be observed after the development of obesity. Thus, blood glucose, lipid, triglyceride, and cholesterol levels may change. These changes bring about a higher risk of cardiovascular disorders (e.g., atherosclerosis or type 2 DM).^[3,9] These metabolic disorders affect the daily activities of life and may cause various psychosocial disorders in obese children. This in turn may lead to the progression of obesity and further increase existing health risks.^[3,12,13] Thus, this study compared obese children and children in other body weight groups in terms of various metabolic parameters.

Childhood obesity is a risk factor for insulin resistance and the development of DM in older ages.^[14] Llewelyn et al. reported that a significant relationship exists between childhood obesity and the development of type 2 DM.^[15]

Furthermore, Anderson et al. stated that children having >85th percentile of BMI are particularly at high risk for type 2 DM.^[13] Blood glucose screening in these children was recommended every 2 years after 10 years old. Moreover, Zimmermann et al. found that in adulthood all BMI values above average were positively associated with type 2 DM.^[16] No significant difference in mean blood glucose levels of obese and non-obese children was noted in this study. Moreover, no correlation was found between BMI and blood glucose level in this study. These data show that obese children are at risk of developing DM. However, obesity may not be directly associated with DM. Thus, hemoglobin A1c (HbA1c) levels, along with blood glucose monitoring, should also be followed up in children with glucose tolerance test done at regular intervals.

Obesity and lipid levels are correlated in children, and this poses a risk for cardiovascular disorders.^[9,17] Childhood obesity is accompanied by a very high triglyceride level and a low HDL-cholesterol level.^[9] Fang et al. and Umeret al. have reported that obesity in children is positively correlated with triglyceride level and negatively correlated with HDL-cholesterol level.^[17,18] Moreover, Suzuki et al. found that BMI is negatively correlated with both LDL-cholesterol and total cholesterol levels in children.^[19] In this study, LDL-cholesterol, total cholesterol, and triglyceride levels were significantly higher in obese children than non-obese children. In addition, this study found a significant positive correlation between BMI and LDL-cholesterol, total cholesterol, and triglyceride levels. However, a significant negative correlation was found between BMI and HDL-cholesterol level. These data show the significant correlation existing between childhood obesity and dyslipidemia. Based on these results, the cholesterol and triglyceride levels of children reported to have high BMI should be closely monitored and treatment should be arranged to decrease the risk of cardiovascular disorders.

An association exists between obesity and hypertension. In recent years, hypertension due to excess weight and obesity is increasing in children.^[10,12,20] Wühlet al. reported that weight gain is a major risk factor for the development of hypertension in children, and weight gain is the culprit in 75% of hypertension cases.^[10] Kelly et al. have reported that children at risk of developing hypertension are 2.6, 3.7, and 4.8 times more in obese, severely obese, and morbidly obese children, respectively, compared with normal-weight children.^[21] Moreover, Zhao et al. reported that BMI and hypertension are significantly correlated.^[22] In another study by Zhao et al. hypertension is three to six times more frequent in obese children compared with normal children.^[23] Umeret al. reported in their meta-analysis that

a significant association exists between childhood obesity and hypertension.^[18] In this study, the ratio of hypertensive children was higher in obese children compared with children in non-obese children group. Moreover, mean SBP and DBP levels were also found to be higher in obese children compared with non-obese children. These data show that both SBP and DBP is higher in obese children. Thus, they are at higher risk of developing hypertension when they become adults. Kelly et al. declared that every 10 kg/m² BMI increase in children enables the increase of mean SBP and DBP at 10 and 3 mmHg, respectively.^[21] Furthermore, Zhao et al. and Basiratniaet al. reported that BMI is significantly correlated with both SBP and DBP levels.^[22-24] In this study, correlation analysis revealed that BMI is significantly correlated with both SBP and DBP levels. Based on these results, the blood pressure levels of children with high BMI should be closely monitored and preventive measures should be established against the development of hypertension.

This study has some limitations. Changes in metabolic indices of the participants could not be observed because this study is retrospective. Moreover, follow-up could not be performed because of the glucose tolerance test and HbA1c. Thus, DM assessment was incomplete. This study found that childhood obesity is closely related to dyslipidemia and hypertension. Moreover, information obtained from this study indicates that close monitoring of SBP and DBP and serum lipid levels of obese children is needed for appropriate risk management to be carried out.

CONCLUSION

The present study revealed that children between 12 to 17 years age were closely related with dyslipidemia and hypertension and childhood obesity might be considered as a risk factor for these co-morbidities. Moreover, close monitoring of SBP and DBP and serum lipid levels obese children is needed to be carried out for appropriate risk management.

Disclosures

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

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Ethics Committee Approval: This study was approved by the Ethics Committee of Umraniye Training and Research Hospital. (Approval date: Dec 18, 2019 and Approval number: 249). Written informed consent was obtained from the participants before they were included in the study.

Authorship Contributions: Concept – S.E., H.S.; Design – S.E., E.P., H.S.; Supervision – S.E., E.P.; Materials – S.E., E.P.; Data collection &/ or processing – H.S., S.E., E.P.; Analysis and/or interpretation – H.S., S.E., E.P.; Literature search – H.S., S.E.; Writing – H.S., S.E., E.P.; Critical review – H.S., S.E., E.P.

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