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ORIGINAL ARTICLE

Prevalence of obesity in prepubertal and pubertal with Turkish population type 1 diabetes

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Abstract

To determine the prevalence of prepubertal and pubertal obesity in children and adolescents with type 1 Diabetes Mellitus (Type 1 DM). One hundred fifty children and adolescents aged 6–18 years with Type 1 DM who attended the Pediatric Endocrinology Polyclinic and were diagnosed with type 1 DM were included in the study. Tanner staging was used to estimate pubertal status. Age- and gender-specific body mass index (BMI) percentile between 85 and 95% was accepted as overweight and >95% as obese. It was determined that the overweight prevalence rates in children and adolescents with type 1 DM were 13.3% and the obesity rate was 14.3%. It was found that while the overweight prevalence rates (14.1%) were higher in males, the obesity prevalence was higher in females (19.0%). The obesity prevalence rates at the prepubertal and pubertal stages were found to be 17.1% and 13.8%, respectively. The obesity prevalence at the pubertal stage was higher in girls (22.4%) than boys (3.9%) ($p<0.05$). The rates both of overweight and obesity in boys decreased from prepubertal to pubertal periods, while those rates increased in girls. Our results indicated that the obesity prevalence in prepubertal and pubertal children and adolescents with type 1 DM was higher compared to healthy peers in the literature. The authors believe that the risk factors for obesity in this population should be determined and obesity-prevention programs for diabetes should be prepared.

Keywords Prepubertal · Pubertal · Obesity · Overweight · Type 1 diabetes

Introduction

Obesity is a chronic disease associated with increased adipose tissue in the body. Obesity is a global public health problem affecting all age groups in society and is increasing dramatically in children and adolescents [1–3]. Obesity has increased 10 times in the past 40 years and the number of affected patients increased from 11 to 124 million [4]. Today, approximately one-third of children in the United States are overweight or obese [5]. According to the results of the National Turkey Nutrition and Health Survey, the prevalence of overweight and obesity in 6–18 years age group was found to be 14.3% and 8.2%, respectively [6].

The obesity prevalence in children and adolescents with Type 1 Diabetes Mellitus (Type 1 DM) is increasing. According to the Diabetes Control and Complications Trial (DCCT)-2009 report, the overweight and obesity prevalence in patients with type 1 DM is 31% [7, 8]. The results of a study carried out in Turkey revealed that children and adolescents with type 1 DM prevalence of obesity of 9.5% and 8.5%, respectively. [9]. The authors believe that the obesogenic environment is important in this increase [10]. Some factors such as modern insulin infusions, continuous subcutaneous insulin infusion, advanced medical care, improved glycemic control, insulin types, frequency of insulin injection, insulin dosage, bolus and basal insulin rates, the frequency of hyperglycemia-hypoglycemia and its treatment, more flexible mealtimes, more frequent snacking and changes in the lifestyle can lead to excessive weight gain in patients with type 1 DM [11, 12]. The increase in Body Mass Index (BMI) is associated with poor metabolic control and increased risk for comorbidity [13].

There is a limited number of studies that examining the overweight and obesity prevalence in children and adolescents with type 1 DM at the national level. Therefore, the

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present study aims at determining the prevalence of prepubertal and pubertal obesity in children and adolescents with Type 1 DM.

Method

This study was carried out between December 2019–June 2020 on 150 children and adolescents aged 6–18 years with type 1 DM who followed up in Bursa Uludağ University Health Applied and Research Center Pediatric Endocrinology Polyclinic. The ethics committee approval no. 2018-14/38 was obtained from Bursa Uludağ University Non-Interventional Clinical Research Ethics Committee and the research permit no. 73115338-819/38160 was obtained from Bursa Uludağ University Directorate for Health Applied and Research Center.

Fifty-five hundred children and adolescents aged 6–18 years who attended to the Pediatric Endocrinology Polyclinic, were diagnosed with type 1 DM (diagnosed at least one year ago), and agreed to participate in the study voluntarily were examined. Those with chronic diseases (thyroid, celiac, etc.) and using obesity-related drugs were excluded from the study.

Children's body weight and height were evaluated using the percentile curves for children developed by Neyzi et al. [14]. To evaluate body weights according to height, 'Body Mass Index (BMI)' was used. Body Mass Index was calculated using the formula, BMI = Body weight (kg)/height (meter)^2. Age- and gender-specific BMI is defined as percentile <5: underweight; percentile ≥ 5 and <85: normal weight; percentile ≥ 85 and <95: overweight; percentile ≥ 95: obesity [15]. A Tanita DC 360 bioelectrical impedance analyzer was used to measure body composition such as body weight (kg), body fat ratio (%), fat mass (kg), and muscle mass (kg).

Fasting blood samples were taken after an overnight fast. Total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG) levels were measured by an automated chemistry analyzer (Aeroset, Abbott, USA) using Abbott commercial kits. HbA1c levels were measured with an Adams™ A1c HA-8160 analyzer and with the same brand kit using HPLC (high-performance liquid chromatography) method.

To evaluate the pubertal status, Tanner staging was used by a Pediatric Endocrinology Specialist and Tanner stage 1 was considered prepubertal and Tanner stage 2–5 as the pubertal stage. [16].

Statistical analysis

All statistical analysis was performed using IBM SPSS Statistics version 23. The Shapiro–Wilk test was used to evaluate the normality of data. Independent Sample *t* test was used to compare two independent populations which are both normally distributed and one-way analysis of variance (ANOVA) was used for comparing more than two independent populations. The obtained data are presented as mean ± standard deviation ($\bar{x} \pm ss$). Mann–Whitney *U* test was used for data that are not normally distributed and Kruskal–Wallis *H* test was used for three or more independent populations and the results were presented with median (minimum–maximum) values. Pearson's chi-squared test, Fisher's exact test, and Fisher–Freeman–Halton test were used to compare categorical variables and the results presented with frequency (n, %) values. A significance level of $\alpha = 0.05$ was adopted in this study [17].

Results

Anthropometric and clinical parameters of the children and adolescents according to BMI percentages are given in Table 1. No differences were observed between groups according to the age at diagnosis of Type 1 DM and diabetes diagnosis period. An examination of insulin doses revealed that obese participants use higher doses of insulin. The difference between total and bolus insulin doses was found to be significant ($p < 0.05$). As BMI percentile increases, HbA1c (%), TC and LDL-C levels increase. However, we found that this correlation was not significant ($p > 0.05$). Regarding the health care provider visits in the past 12 months, while the number of visits is similar for normal weight and overweight individuals, it is significantly higher for obese individuals ($p < 0.05$).

Total daily, basal and bolus insulin doses, HbA1c (%) level and triglyceride concentrations of patients at the pubertal stage were significantly higher compared to those at the prepubertal stage (Table 2).

The overweight prevalence ratio in children and adolescents with Type 1 DM for girls and boys was found to be 12.6% and 14.1%, respectively and the obesity rate 19.0% and 9.9%, respectively (Fig. 1).

The overweight prevalence at prepubertal and pubertal stages was calculated as 17.1% and 11.9%, respectively. The obesity prevalence in the prepubertal period was determined as 17.1% and the in pubertal period 13.8% (Fig. 2).

The overweight prevalence rates in prepubertal and pubertal girls were calculated as 9.5% and 13.8%,

Table 1 Anthropometric and clinical parameters of the participants according to BMI percentiles

	Normal (*n*:108)	Overweight (*n*:20)	Obesity (*n*:22)	*p*	Total ($n = 150$)
Age (years)	12.4 ± 3.0	11.5 ± 3.3	11.8 ± 3.1	0.378	12.2 ± 3.1
Body weight (kg)	44.5 ± 14.7	47.2 ± 16.4	53.6 ± 14.5	0.036	46.2 ± 15.1
Body weight (percentile)	44.5 (1.0–88.2)	86.3 (49.6–99.5)	95.2 (50.4–99.7)	< 0.000	7.3 (1.0–99.7)
Height (cm)	149.9 ± 16.8	144.5 ± 18.1	144.3 ± 13.1	0.189	148.4 ± 16.5
Height (percentile)	42.6 (0.2–97.0)	51.4 (5.9–99.8)	40.7 (0.1–86.2)	0.610	43.2 (0.3–99.8)
BMI (kg/m^2)	19.1 ± 2.6	21.7 ± 2.3	25.0 ± 3.1	< 0.001	20.0 ± 3.4
BMI (percentile)	49.1 (2.4–84.6)	88.1 (85.0–93.6)	97.0 (95.0–99.9)	< 0.001	61.4 (2.1–99.9)
Waist circumference (cm)	67.3 ± 9.9	72.0 ± 10.5	79.9 ± 11.9	< 0.001	69.8 ± 11.1
Hip circumference (cm)	82.7 ± 11.3	86.3 ± 13.7	91.6 ± 13.7	0.006	84.5 ± 02.3
Waist/hip ratio	0.83 ± 0.16	0.84 ± 0.05	0.87 ± 0.06	0.423	0.83 ± 0.14
Body fat mass (kg)	7.1 (2.8–20.5)	11.3 (5.4–23.4)	17.1 (6.0–28.6)	< 0.001	10.5 (2.8–28.6)
Body fat ratio (%)	19.2 ± 5.9	25.8 ± 5.2	32.4 ± 4.7	< 0.001	22.0 ± 7.4
Fat-free body weight (kg)	35.4 ± 11.9	35.2 ± 12.9	35.9 ± 8.9	0.086	35.6 ± 11.6
Body muscle mass (kg)	33.4 ± 11.1	33.4 ± 12.4	33.9 ± 8.5	0.085	33.8 ± 11.1
Type 1 DM age at diagnosis (years)	7.0 ± 3.2	6.0 ± 3.7	7.1 ± 3.1	0.444	6.9 ± 3.3
Duration of type 1 DM (years)	5.2 ± 3.2	5.9 ± 3.4	5.2 ± 3.6	0.716	4.8 (1.1–16.3)
Total insulin dose (U/day)	41.0 (16.0–76.0)	37.0 (15.0–73.0)	58.5 (21.0–91.5)	0.009	42.0 (15.0–128.0)
Insulin dose (U/kg/day)	0.91 ± 0.2	0.88 ± 0.2	0.89 ± 0.2	0.106	0.92 ± 0.2
Basal insulin (U/day)	16.0 ± 7.1	16.6 ± 7.7	20.2 ± 7.9	0.070	16.0 (5.0–38.0)
Bolus insulin (U/day)	24.3 ± 9.3	27.4 ± 11.2	37.5 ± 12.5	0.005	24.7 (8.0–98.0)
HbA1c (%)	9.1 ± 1.8	9.5 ± 1.1	10.2 ± 2.5	0.137	9.4 (6.4–17.0)
TC (mg/dL)	163.7 ± 31.2	169.3 ± 32.8	174.0 ± 33.7	0.359	165.9 ± 31.8
HDL-C (mg/dL)	53.6 ± 14.0	56.1 ± 15.2	49.1 ± 17.2	0.310	53.3 ± 14.7
LDL-C (mg/dL)	89.6 ± 25.0	97.0 ± 27.2	102.6 ± 26.4	0.087	92.4 ± 25.8
Triglycerides (mg/dL)	92.9 (28.0–274.6)	93.1 (48.0–192.2)	127.4 (48.0–267.0)	0.039	87.0 (28.0–274.6)
DBP (mmHg)	72.8 ± 9.2	72.5 ± 12.7	77.3 ± 9.4	0.136	73.4 ± 9.8
SBP (mmHg)	106.8 ± 11.2	106.2 ± 13.1	109.1 ± 13.8	0.049	108.0 ± 12.1
Carbohydrate count	20 (13.3%)	6 (4.0%)	6 (4.0%)	0.717	32 (21.3%)
CSII	19 (12.7%)	6 (4.0%)	5 (3.3%)	0.418	30 (20.0%)
Visits to allied healthcare provider in last 12 months	2 (0–6)	2 (0–6)	4 (0–7)	0.003	2 (0–7)

BMI body mass index; *TC* total cholesterol; *HDL-C* high-density lipoprotein cholesterol; *LDL-C* low-density lipoprotein cholesterol; *CSII* continuous subcutaneous insulin infusion

Data are expressed as mean (SD), median (interquartile) or number (%) of subjects. *p*-values by one-way analysis of variance for continuous variables and Chi^2 test for categorical variables

respectively; and in boys 25.0% and 9.8%, respectively. The obesity prevalence in prepubertal and pubertal girls were calculated 9.5% and 22.4%, respectively, and in boys 25.0% and 3.9%, respectively. Obesity prevalence rate was significantly higher in pubertal girls (22.4%) than those boys (3.9%) ($p < 0.05$) (Figs. 3, 4).

Correlations between participants' metabolic and glycemic parameters and BMI percentiles are given in Table 3. Low correlations were found between LDL-C, triglycerides, total insulin dose, basal and bolus insulin (U/day) and BMI percentiles ($p < 0.05$). On the other hand, no correlation was determined between HbA1c (%) and BMI percentiles.

Discussion

In the present study, the obesity prevalence rates in children and adolescents with type 1 DM were calculated as 17.1% at the prepubertal and 13.8% at the pubertal stage. In another study with type 1 DM in Turkey, this ratio was calculated as 9.5% in children and 8.5% in adolescents [9]. According to Turkey Nutrition and Health Research data, the prevalence of obesity in children aged 6–18 was 11.4% in the eastern Marmara region of Turkey, where this study was conducted. This ratio is higher compared to other regions of Turkey [6]. Therefore, the reason for

Table 2 Anthropometric measurements and clinical information by gender at prepubertal and pubertal stages

	Girl			Boy		
	Prepuberty (*n*:21)	Puberty (*n*:58)	*p*	Prepuberty (*n*:20)	Puberty (*n*:51)	*p*
Age (years)	8.8 ± 1.7	13.5 ± 2.3	< 0.000	8.7 ± 1.7	13.5 ± 2.6	< 0.000
Body weight (kg)	29.9 ± 7.9	52.2 ± 12.1	< 0.000	32.2 ± 8.9	51.6 ± 14.2	< 0.000
Body weight (percentile)	49.2 ± 21.8	42.7 ± 28.3	0.267	65.0 ± 25.7	49.1 ± 26.8	0.011
Height (cm)	129.1 ± 9.7	153.5 ± 9.5	< 0.000	129.6 ± 8.9	157.8 ± 15.3	< 0.000
Height (percentile)	35.5 ± 21.7	42.8 ± 28.3	0.162	41.8 ± 19.6	49.1 ± 26.8	0.269
BMI (kg/m^2)	17.6 ± 2.3	21.9 ± 3.7	< 0.000	18.8 ± 3.3	20.2 ± 2.5	0.055
BMI (percentile)	60.1 ± 20.1	74.6 (2.4–99.1)	0.242	69.7 ± 26.9	46.8 (6.0–97.7)	0.055
Waist circumference (cm)	59.8 ± 7.9	74.4 ± 11.2	< 0.000	61.7 ± 7.4	72.0 ± 9.0	0.002
Hip circumference (cm)	71.6 ± 8.6	91.0 ± 10.3	< 0.000	72.5 ± 8.9	87.2 ± 9.5	< 0.000
Waist/hip ratio	0.83 ± 0.04	0.84 ± 0.21	0.793	0.85 ± 0.06	0.82 ± 0.05	0.093
Body fat mass (kg)	5.9 (3.3–16.1)	14.9 ± 6.1	< 0.000	6.2 (2.8–14.8)	8.4 ± 3.4	0.068
Body fat ratio (%)	22.0 ± 4.9	27.5 ± 6.4	< 0.000	21.1 ± 5.7	16.2 ± 5.1	< 0.000
Fat-free body weight (kg)	22.9 ± 5.0	37.3 ± 7.0	< 0.000	25.0 ± 6.2	43.1 ± 12.1	< 0.000
Body muscle mass (kg)	21.7 ± 4.8	35.4 ± 6.8	< 0.000	23.6 ± 6.0	40.9 ± 11.5	< 0.000
Duration of type 1 DM (years)	4.1 ± 2.0	6.1 ± 3.7	0.026	3.6 ± 1.9	5.5 ± 3.3	0.018
Total insulin dose (U/day)	25.0 (17.0–65.0)	50.6 ± 15.2	< 0.000	24.0 (16.0–44.0)	46.8 ± 17.9	< 0.000
Insulin dose (U/kg/day)	0.89 ± 0.2	0.97 ± 0.02	0.117	0.85 ± 0.2	0.90 ± 0.02	0.185
Basal insulin (U/day)	9.0 (6.0–22.0)	20.2 ± 6.6	< 0.000	8.0 (5.0–16.0)	18.3 ± 6.8	< 0.000
Bolus insulin (U/day)	16.0 (10.0–49.0)	30.0 (12.0–53.0)	< 0.000	16.0 (8.0–29.0)	25.0 (13.0–98.0)	< 0.000
Bolus/total insulin ratio (%)	0.61 (0.56–0.75)	0.60 ± 0.06	0.141	0.65 (0.44–0.76)	0.60 ± 0.07	0.060
Basal/bolus insulin ratio	0.62 (0.33–0.80)	0.65 (0.40–1.56)	0.134	0.53 (0.31–1.25)	0.64 (0.31–1.56)	0.055
HbA1c (%)	8.9 ± 1.2	10.1 ± 1.9	0.019	9.1 ± 1.3	9.4 ± 1.9	0.130
TC (mg/dL)	157.7 ± 28.4	173.7 ± 35.3	0.066	161.7 ± 26.7	162.0 ± 29.7	0.967
HDL-C (mg/dL)	92.0 (41.6–195.1)	118.2 (58.2–274.7)	0.061	63.2 (40.0–261.1)	85.6 (28.0–273.3)	0.084
LDL-C (mg/dL)	53.0 ± 12.9	50.9 ± 14.4	0.567	64.5 ± 17.0	51.7 ± 13.1	0.011
Triglycerides (mg/dL)	83.7 ± 22.2	99.8 ± 27.4	0.018	82.8 ± 19.1	98.2 ± 34.4	0.021
DBP (mmHg)	68.6 ± 6.7	75.7 ± 10.7	0.005	66.9 ± 8.6	75.3 ± 8.7	< 0.000
SBP (mmHg)	100.6 ± 7.6	111.4 ± 13.4	0.001	100.0 ± 12.8	110.2 ± 9.0	< 0.000
Carbohydrate count	4 (5.1%)	8 (10.1%)	0.668	8 (11.3%)	12 (16.9%)	0.617
CSII	4 (5.1%)	11 (13.9%)	0.612	5 (7.0%)	10 (14.1%)	0.126

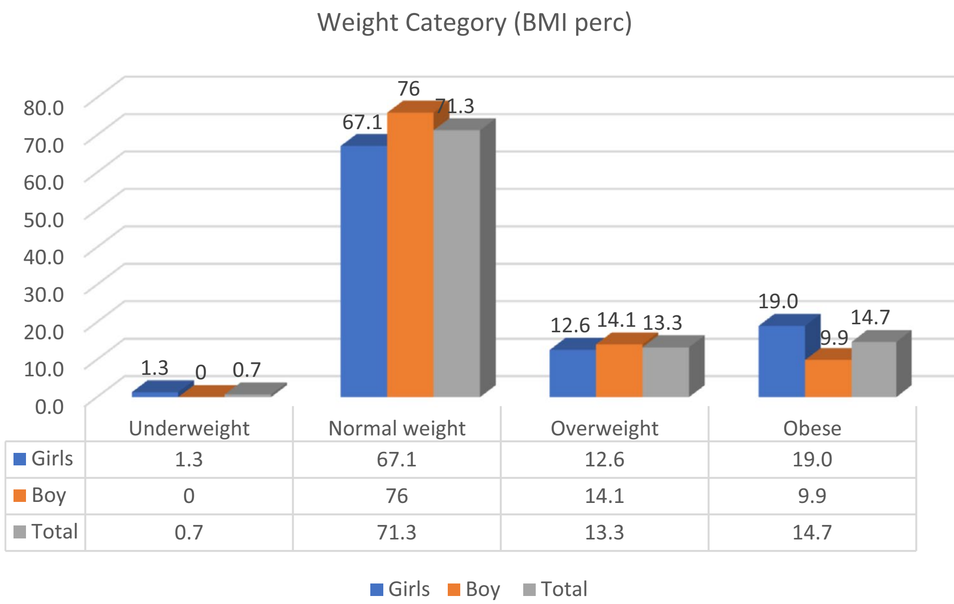
BMI body mass index; *TC* total cholesterol; *HDL-C* high-density lipoprotein cholesterol; *LDL-C* low-density lipoprotein cholesterol; *CSII* continuous subcutaneous insulin infusion

Data are expressed as mean (SD), median (interquartile) or number (%) of subjects. *p*-values by one-way analysis of variance for continuous variables and Chi^2 test for categorical variables

the higher obesity prevalence rates in children and adolescents with type 1 DM in our study than the ratio found by Köken et al. [9] is thought to be caused by regional differences. According to the National Paediatric Diabetes Audit (NPDA) 2018–2019 report, the overweight prevalence rates in children (0–11 years) and adolescents with type 1 DM were found as 17.7% and 18.4%, respectively and the obesity prevalence rates were 18.1% and 23.6% [18]. Our results regarding the obesity prevalence are similar to the study by Gilbertson et al. [19] and higher than the study of Hamiel et al. [20]. These findings can be associated with the fact that childhood obesity continues to rise in Turkey and the obesity prevalence is higher than in other countries [2].

It was reported that with the diagnosis of Type 1 DM, the risk of obesity increases 7 times based on the duration of DM [13]. According to the SEARCH for Diabetes in Youth study (SEARCH), the overweight and obesity prevalence in children and adolescents with type 1 DM was determined as 34.7% (overweight 22.1% and obesity 12.6%) in the US [21]. In the current study, the overweight and obesity prevalence rates at the pubertal stage (25.7%) was higher than those calculated by National Turkey Nutrition and Health Survey (23.8%) in healthy adolescents (12–14 years) [6]. It

Fig. 1 BMI percentile distributions by gender in the total population



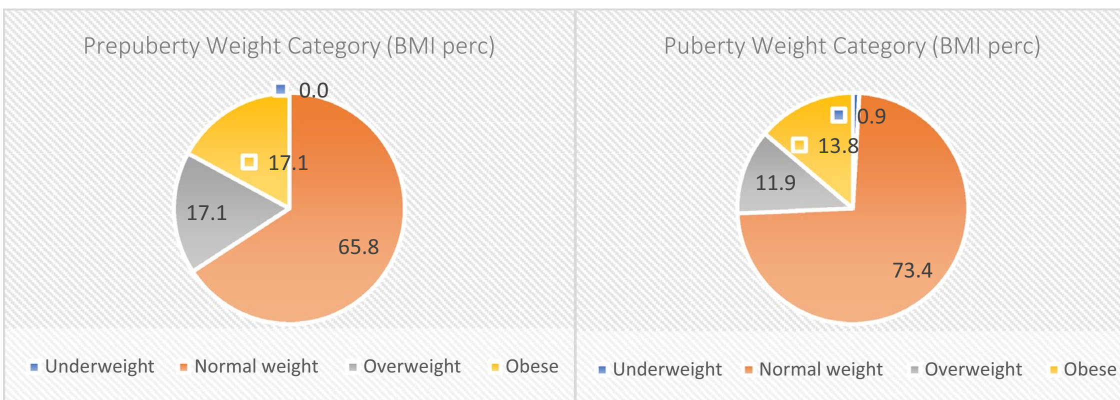


Fig. 2 BMI percentile distribution in prepubertal and pubertal period

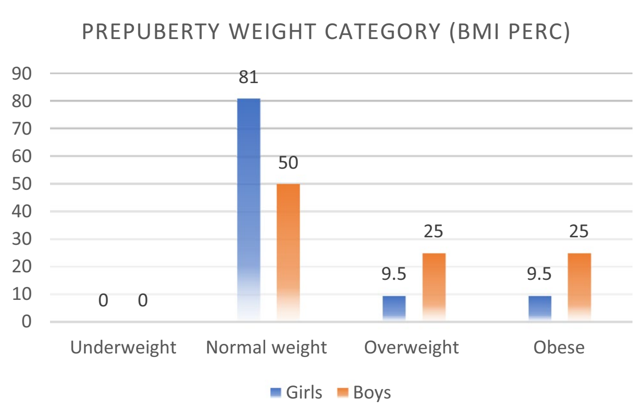


Fig. 3 BMI percentile distribution by age and gender in prepubertal period

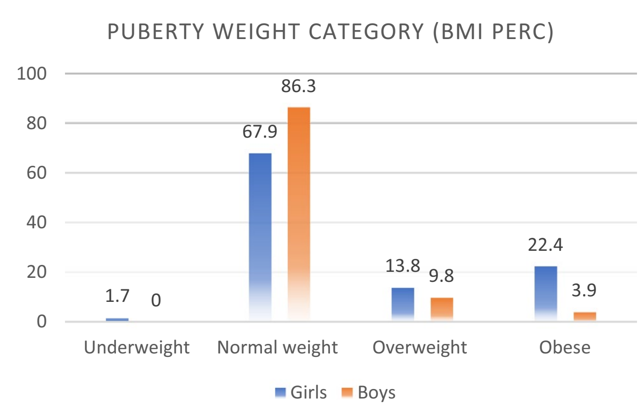


Fig. 4 BMI percentile distribution by age and gender in pubertal period

Table 3 Correlations between BMI percentiles and metabolic and glycemic parameters

	BMI Percentil	
	r	*p*
Toplam insülin dozu (U/gün)	0.255	0.002
Basal insulin (U/day)	0.183	0.025
Bolus insulin (U/day)	0.277	0.002
HbA1c (%)	0.137	0.095
DBP (mmHg)	0.141	0.085
SBP (mmHg)	0.213	0.009
TC (mg/dL)	0.117	0.152
HDL-C (mg/dL	−0.073	0.376
LDL-C (mg/dL)	0.187	0.022
Triglycerides (mg/dL)	0.181	0.027

is known that the higher prevalence rates of overweight and obesity among people with diabetes might be explained by diabetes-related obesity risk factors in patients with Type 1 DM [22]. Consistent with our findings, in a study carried out by SWEET (Better control in Pediatric and Adolescent diabeteS: Working to crEate CEnTers of Reference), it was found that adolescents with type 1 DM have higher BMI than their healthy peers [10]. However, when examined by gender, the obesity rate in adolescent boys with Type 1 DM (3.9%) was found to be lower than healthy adolescent boys (4.8–6.9%) in our study [23, 24]. This difference may be due to sample size, regional differences, age range, and differences in anthropometric cut-off points used in the assessment of obesity.

Several reports pointed out that the Body Mass Index (BMI) *z*-scores in children with type 1 DM gradually increases in the first 6 years after diagnosis [11, 12]. It was reported that the administration of supraphysiological doses of insulin in children with Type 1 DM to achieve glycemic targets causes body weight increase [22]. In adolescence, body composition changes depending on hormonal changes in addition to gender difference, biological, and social factors. Recent studies reported that among patients with Type 1 DM, girls are more insulin resistant than boys and insulin resistance is associated with a higher tendency to gain weight [20, 25]. Prinz et al. stated that for the patients followed up from childhood to young adulthood, the increase in BMI z-scores of girls with type 1 DM was higher than boys. The reason for this was explained as the diagnosis, treatment, and psychological burden of diabetes influence girls more than boys [25]. Moreover, the higher overweight and obesity prevalence among pubertal girls with Type 1 DM than boys is explained by the difference in adipose tissue accumulation between girls and boys as well as the change in insulin sensitivity during pubertal transition in girls due to increased activity of sex hormones [20]. Liu et al. conducted a study on patients with Type 1 DM and found that the overweight and obesity prevalence in non-Hispanic white girls and boys aged 3–11 were 26.6% and 34.2%, respectively; and in girls and boys aged 12–19 were 36.5% and 28.8%, respectively [21]. In the US, it was reported that the obesity prevalence rates in adolescent girls (13.6%) with type 1 DM is higher than those boys (12.7%) ($p < 0.01$) [26]. Similarly, we found that the obesity prevalence rates at the pubertal stage was higher in girls (22.4%) compared to boys (3.9%) ($p < 0.05$). In addition to the previous studies [20, 21, 27], in our study, the higher duration of Type 1 DM, poor glycemic control, higher rates of HbA1c and insulin doses in girls than boys might have contributed to higher overweight and obesity prevalence among pubertal girls with Type 1 DM than boys. Furthermore, in the traditional Turkish family structure, girls are shown a more protective behavior than boys and therefore, girls spend more inactive time at home. Such protective behavior increases more with the diabetes situation. The fact that girls with Type 1 DM avoid physical activity with the concern for hypoglycemia and higher consumption of high-energy traditional Turkish food in the home environment might be associated with higher overweight and obesity prevalence among pubertal Turkish girls with Type 1 DM than boys.

Increased BMI is associated with worse metabolic control and increased risk of comorbidity. Moreover, clinical studies indicated that the increase in body weight in type 1 DM is associated with metabolic syndrome, the risk of micro and macrovascular diseases, additionally, this risk is lower in those with better glycemic control [13]. However, Minges et al. found that adolescents with Type 1 DM who have better metabolic control also have a higher risk for overweight. Moreover, they determined that this risk is higher in obese adolescents [26]. In our study, a positive correlation was found between BMI percentiles of the patients with Type 1 DM and metabolic and DM-related parameters. It was reported that children who have obesity are more likely to become adults with obesity and the duration of diabetes is positively associated with weight gain. Obesity in people with type 1 diabetes is a condition that affects many areas including genetics, epigenetics, enteroendocrine hormones and the microbiome as well as many cells, tissues, and organs. Furthermore, people with type 1 diabetes also display behavioral, psychological, and social causes that trigger obesity. It was recommended to prepare body weight control guidelines for obese people with type 1 DM by determining these causes [28].

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Compliance with ethical standards

Conflicts of interest The authors declare no conflict of interest.

Informed consent Written informed consent was taken from the parents of all patients. The study conformed to the provision of the Declaration of Helsinki.

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