RESEARCH ARTICLE

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Comparison of Anterior Segment Measurements in Obese Children and Healthy Control Group

ABSTRACT

Objective: To evaluate anterior segment parameters in obese children.

Methods: Fifty-five obese and 30 control group children subjects participated. All participants and the control group were examined and anthropometric measurements were made. The measurements of fasting blood glucose (FBG), systolic blood pressure (SBP) triglyceride (TG), total cholesterol (TC), high-density lipoprotein-cholesterol (HDL-C), low-density lipoprotein-cholesterol (LDL-C), and insulin values were performed. The homeostasis model assessment of insulin resistance (HOMA-IR) was calculated. Each participant underwent a detailed ophthalmic examination and intraocular pressure (IOP), central corneal thickness (CCT), anterior chamber depth (ACD) and lens thickness (LT) were measured.

Results: The gender distribution of the groups was similar (p=0.893). The mean of CCT and LT were significantly higher in the obese group (572.9 ± 14.5 vs. 559.5 ± 10.1 µm, p=0.001; 3.6 ± 0.14 vs. 3.48 ± 0.25 mm, p=0.007). No significant difference was found between the obese and control groups in terms of other parameters. Body mass index (BMI) and waist circumference (WC) had a significant negative correlation with LT control groups. The obese group showed a significant positive correlation between IOP and TG (r=0.276, p=0.042), and a significant negative correlation with HDL-C (r=-0.273, p=0.043). In the control group, there was a significant positive correlation between IOP and BMI (r=0.389, p=0.034), WC (r=0.497, p=0.005), HOMA-IR (r=0.384, p=0.036), Insulin (r=0.407, p=0.026), and a significant negative correlation with TC (r=-0.511, p=0.004). A significantly positive correlation between ACD and LDL-C (r=0.371, p=0.043) and a significantly negative correlation between HOMA-IR in the control group were detected (r=-0.682, p=0.000).

Conclusions: The obese group had higher CCT and LT than the control groups.

Keywords: Obese Children, Corneal Thickness, Anterior Chamber Depth, Lens Thickness, Intra Ocular Pressure.

Obez Çocuklarda ve Sağlıklı Kontrol Grubunda Ön Segment Ölçümlerinin Karşılaştırılması

ÖZET

Amaç: Obez çocuklarda ön segment parametrelerinin değerlendirilmesi.

Gereç ve Yöntem: Elli beş obez ve 30 kontrol grubu çocuk denek katıldı. Tüm katılımcılar ve kontrol grubu incelendi ve antropometrik ölçümler yapıldı. Açlık kan şekeri (AKŞ), trigliserit (TG), toplam kolesterol (TK), yüksek yoğunluklu lipoprotein-kolesterol (HDL-K), düşük yoğunluklu lipoprotein-kolesterol (LDL-K) ve insülin değerleri ölçümleri yapıldı. . İnsülin direncinin (HOMA-IR) homeostaz modeli değerlendirmesi hesaplandı. Her katılımcıya detaylı bir göz muayenesi yapıldı ve Göz içi basıncı (GİB), Santral kornea kalınlığı (SKK), Ön kamara derinliği (ÖKD) ve Lens kalınlığı (LK) ölçüldü.

Bulgular: Grupların cinsiyet dağılımı benzerdi (p=0,893). SKK ve LK ortalaması obez grupta anlamlı olarak daha yüksekti (572.9 ± 14.5'e karşılık 559.5 ± 10.1 µm, p=0.001; 3.6 ± 0.14'e karşı 3.48 ± 0.25 mm, p=0.007). Obez ve kontrol grupları arasında diğer parametreler açısından anlamlı fark bulunmadı. Vücut kitle indeksi (VKİ) ve bel çevresi (BÇ), LK kontrol grupları ile anlamlı bir negatif korelasyona sahipti. Obez grup, GİB ile TG arasında anlamlı bir pozitif korelasyon (r=0.276, p=0.042) ve HDL-K ile anlamlı bir negatif korelasyon gösterdi (r=-0.273, p=0.043). Kontrol grubunda GİB ile VKİ (r=0.389, p=0.034), WC (r=0.497, p=0.005), HOMA-IR (r=0.384, p=0.036), İnsülin arasında anlamlı pozitif ilişki vardı. (r=0.407, p=0.026) ve TK ile anlamlı bir negatif korelasyon (r=-0.511, p=0.004). Kontrol grubunda ÖKD ile LDL-K arasında anlamlı pozitif korelasyon (r=0.371, p=0.043) ve HOMA-IR arasında anlamlı derecede negatif korelasyon saptandı (r=-0.682, p=0.000).

Sonuç: Obez grup, kontrol gruplarına göre daha yüksek SKK ve LK'ye sahipti.

Anahtar Kelimeler: Obez Çocuklar, Kornea Kalınlığı, Ön Kamara Derinliği, Lens Kalınlığı, Göz İçi Basıncı.

INTRODUCTION

Obesity is a condition characterized by excessive weight that is associated with negative health outcomes (1). The prevalence of obesity in the United States continues to rise at an alarming rate, affecting approximately 10% of infants and toddlers, 17% of children and teenagers, and over 30% of adults (2). The interplay of physical and environmental factors lays the foundation for childhood obesity. The regulation of weight through neuroendocrine mechanisms involves various instances where genetic variations may influence an individual's weight status. Unfortunately, children are more vulnerable than ever to obesity and related weight disorders due to inadequate dietary and exercise environments.

The long-term consequences of childhood obesity on an individual's health are significant. Obesity negatively impacts both physical and mental well-being and increases the risk of various conditions, including atherosclerosis, diabetes mellitus, hypertension, sleep apnea, nonalcoholic fatty liver disease (NAFLD), precocious puberty, gynecomastia, polycystic ovary syndrome, and steatohepatitis (3). In a study by Bergman et al., it was suggested that a higher body mass index (BMI) may be associated with decreased visual acuity, although the exact ocular conditions contributing to this relationship and their underlying mechanisms remain unclear (4). Furthermore, obesity also raises the risk of vision loss associated with age-related macular degeneration, diabetic retinopathy, cataracts, and glaucoma (5).

Ocular problems in obesity may be related to disorders of the mechanical and vascular functions of the eye, which may be due to chronic oxidative stress. Therefore, obesity may worsen visual function even in the absence of related diseases or in the preclinical phases(6,7). While the cornea of a child reaches adult thickness by the age of 3, there have been few reports documenting normal central corneal thickness (CCT) measurements in children's eyes(8). Although intraocular pressure (IOP) and CCT have been extensively studied in relation to obesity, there is no definitive data on whether obesity affects anterior chamber depth (ACD). Only a few studies have evaluated anterior segment measurements in children with obesity. The aim of this study is to assess BMI and adiposity markers, metabolic parameters, and ocular parameters such as IOP, CCT, ACD, and lens thickness (LT) in obese children compared to healthy children. CCT has emerged as an important predictor of progression in glaucomatous damage.

MATERIAL AND METHODS

This prospective study was conducted at the Departments of Ophthalmology and Pediatric Endocrinology at the University School of Medicine. The study received approval from the ethics committee (Clinical Research Registration number: 2017-34) and was conducted in accordance with the principles of the Declaration of Helsinki. Informed consent and oral assent were obtained from each patient and/or their legal guardians.

Fifty-five obese children and 30 age- and gender-matched subjects from a control group participated in the study. Participants who had been diagnosed with systemic diseases, had a history of ocular pathology that could affect central corneal thickness (CCT) and intraocular pressure (IOP) (such as irregular astigmatism or large regular astigmatism ≥3 diopters), ocular hypertension, glaucoma, uveitis, corneal pathology, or were uncooperative during ophthalmic measurements, were excluded from the study.

All participants, including those in the control group, underwent physical examinations, and anthropometric measurements were taken. The children's weight and height were measured with light clothing and without shoes. Body mass index (BMI) is the most commonly used method in clinics to determine overweight and obesity. The BMI formula used for each child was: weight (kg) / height (m)2. BMI above the 95th percentile for age and gender was defined as obesity (8). Waist circumference (WC) was calculated using a measuring tape, with the measurement taken as the nearest half-centimeter midway between the iliac crest and lower rib margin. Blood pressure was measured using a digital automatic sphygmomanometer (Omron® M2 HEM-7121-E, Omron® Healthcare Co, Japan) after a resting period, and measurements were repeated at least three times with a 10-minute interval. Systolic and/or diastolic blood pressure higher than the 95th percentile was defined as hypertensive (9).

A comprehensive ophthalmic examination was performed on all participants, including assessment of best corrected visual acuity using a Snellen chart, slit-lamp biomicroscopy for examination of the anterior and posterior segments of the eye. The measurements were conducted by an experienced ophthalmologist (MTE). Following the ophthalmological examination, intraocular pressure (IOP) and central corneal thickness (CCT) were measured using a non-contact tonometer (Canon TX-20P, Tokyo, Japan). Three measurements were taken for each eye using the non-contact tono/pachymeter devices, and the averages were used for statistical analysis. Anterior chamber depth (ACD) and lens thickness (LT) were measured using the IOL Master 700 (Carl Zeiss Meditec AG, Jena, Germany). A single measurement was taken for each eye using the IOL Master 700.

Statistical Analysis: Descriptive statistics of the data were given as mean, standard deviation (SD), median, first quartile and third quartile, minimum and maximum values for numerical variables, while numbers and percentage frequencies were given for categorical features. The

Shapiro-Wilks test was used to analyze whether the numerical variables fit the normal distribution in both groups. Since the values of numerical variables did not show the normal distribution in at least one group, nonparametric tests were used in data analysis. The two groups were compared for numerical characteristics using the Mann-Whitney U test and correlations between numerical characteristics in each group were analyzed using Spearman rank correlation analysis. The distribution of genders into groups was evaluated by Pearson chi-square analysis. The statistical significance level was considered as P<0.05 and SPSS (ver. 23) program was used for calculations.

RESULTS

Fifty five obese patients, 23 of whom were male (41.8%) and 30 people of the control group, 13 of whom were male (43.3%) participated in the study. The gender distribution of both groups was similar (P=0.893). Descriptive statistics of demographic measurements and group comparison results are given in Table 1. When the table is examined, the obese and control groups showed no difference in terms of systolic and diastolic blood pressures and age, while the mean HDL-C was found to be significantly lower in the patients (46.11 ± 10.45 vs. 55.60 ± 15.13 mg/dl, p=0.020) and WC (90.74. ± 12.18 vs. 56,97 ± 5.27 cm, p<0.001), fasting blood glucose (FBG) (94.16 ± 7.42 vs. 87.40 ± 7.83 mg/dl, p=0.01), TG (121.42 ± 77.10 vs. 52.80 ± 10.68 mg/dl, p<0.001), TC (165.27 ± 51.97 vs. 128.87 ± 16.86 mg/dl, p<0.001), LDL-C (94.32 ± 38.45 vs. 57.77 ± 13.11 mg/dl, p<0.001), HOMA-IR (3.85 ± 212. vs. 1.34 ± 0.34, p<0.001), insülin (16.31 ± 9.10 vs. 6.16 ± 1.78 µIU/ml, p<0.001) significantly higher in the obese group in all the remaining measurements.

Table 1. Descriptive statistics of demographic measurements and group comparison results

	Groups	N	Mean	SD	Min	Max	Percentiles			P
							1st Quartile	Median	3rd Quartile	
Age	ObeseGrup	55	11.15	3.14	6.00	17.00	8.00	11.00	14.00	0.135
	Control Grup	30	10.03	2.44	6.00	17.00	8.00	11.00	12.00	
BMI	ObeseGrup	55	27.17	4.70	19.43	38.81	23.37	26.38	31.31	**<0.001**
	Control Grup	30	19.30	1.58	16.40	22.00	18.50	19.75	20.00	
WC	Obese Grup	55	90.74	12.18	65.00	114.00	80.00	93.00	99.00	**<0.001**
	Control Grup	30	56.97	5.27	50.00	65.00	51.00	58.00	61.00	
Systolic BP	Obese Grup	55	115.82	11.34	90.00	135.00	110.00	115.00	125.00	0.998
	Control Grup	30	115.67	3.88	110.00	120.00	113.75	115.00	120.00	
Diastolic BP	Obese Grup	55	75.73	9.59	50.00	90.00	70.00	80.00	80.00	0.218
	Control Grup	30	74.67	3.92	70.00	80.00	70.00	75.00	80.00	
FBG	Obese Grup	55	94.16	7.42	80.00	112.00	88.00	93.00	99.00	**0.001**
	Control Grup	30	87.40	7.83	71.00	99.00	84.75	90.00	91.25	
TG	Obese Grup	55	121.42	77.10	45.00	434.00	76.00	100.00	147.00	**<0.001**
	Control Grup	30	52.80	10.68	36.00	80.00	44.00	54.50	57.00	
TC	Obese Grup	55	165.27	51.97	48.00	377.00	134.00	150.00	174.00	**<0.001**
	Control Grup	30	128.87	16.86	94.00	162.00	118.60	128.00	141.50	
HDL-C	Obese Grup	55	46.11	10.45	25.00	73.00	40.00	46.00	51.00	**0.020**
	Control Grup	30	55.60	15.13	38.00	83.00	40.00	55.00	67.25	
LDL-C	Obese Grup	55	94.32	38.45	54.20	296.60	70.40	84.40	108.40	**<0.001**
	Control Grup	30	57.77	13.11	38.00	90.00	45.00	58.00	63.25	
HOMA-IR	Obese Grup	55	3.85	2.12	1.01	9.83	2.08	3.68	4.96	**<0.001**
	Control Grup	30	1.34	.34	.84	2.05	1.19	1.28	1.51	
Insulin	Obese Grup	55	16.31	9.10	4.67	45.78	10.49	15.00	19.96	**<0.001**
	Control Grup	30	6.16	1.78	3.90	9.10	4.93	6.00	7.15	

Abbreviations: N,number; SD,standard deviation; BMI, body mass index (kg/m2); WC, waist circumference (in cm); SBP, systolic blood pressure (mmHg); DBP, diastolic blood pressure (mmHg); FBG, fasting blood glucose (mg/dl); TG, triglycerides (mg/dl); TC, total cholesterol (mg/dl); HDL-C, high density lipoprotein- cholesterol (mg/dl); LDL-C, low density lipoprotein- cholesterol (mg/dl); HOMA-IR, Homeostatic Model Assessment for Insulin Resistance; Insulin, µIU/ml.

Descriptive statistics and group comparison results of ocular measurements are given in Table 2. When the table was examined, it was seen that the mean of CCT and LT were significantly higher in the obese group (572.9 ± 14.5 vs. 559.5 ± 10.1 µm, p=0.001; 3.6 ± 0.14 vs. 3.48 ± 0.25 mm, p=0.007) . No significant difference was found between the obese and control groups in terms of other parameters.

Table 2. Descriptive statistics and group comparison results of ocular measurements

	Groups	N	Mean	SD	Min	Max	Percentiles			P
							1st Quartile	Median	3rd Quartile	
IOP	Obese Grup	55	16.0	2.92	9.0	21.0	14.0	16.0	18.0	0.067
	Control Grup	30	14.8	2.50	11.0	19.0	13.5	15.0	17.2	
CCT	Obese Grup	55	572.9	14.5	535.0	608.0	563.0	573.0	581.0	**0.001**
	Control Grup	30	559.5	10.1	545.0	576.0	552.5	558.0	565.0	
ACD	Obese Grup	55	3.4	0.2	2.7	4.3	3.2	3.4	3.6	0.133
	Control Grup	30	3.3	0.3	2.7	3.8	3.2	3.3	3.5	
LT	Obese Grup	55	3.6	0.14	3.28	3.85	3.49	3.62	3.69	**0.007**
	Control Grup	30	3.48	0.25	2.53	3.77	3.47	3.53	3.67	

Abbreviations:N,number; SD,standard deviation; IOP, intraocular pressure (mmHg); CCT, central corneal thickness (µm); ACD, anterior chamber depth (in mm); LT, lens thickness (in mm).

When the correlations between anthropometric and metabolic characteristics and Ocular measurements were examined separately in both groups, the results given in Table 3 were obtained. When Table 3 was examined, no ocular parameter was found that had a significant relationship with age, systolic blood pressure (SBP) and FBG in both groups. BMI and WC were found to have a significant negative correlation with LT control groups. The obese group showed a significant positive correlation between IOP and TG (r=0.276, p=0.042) and a significantly negative correlation with HDL-C (r=-0.273, p=0.043). In the control group, there was a significant positive correlation between IOP and BMI (r=0.389, p=0.034), WC (r=0.497, p=0.005), HOMA-IR (r=0.384, p=0.036), Insulin (r=0.407, p=0.026), and a significant negative correlation with TC (r=-0.511, p=0.004). It was determined that there was no correlation between the anthropometric and metabolic characteristics of the obese group and CCT and ACD, a significantly positive correlation between ACD and LDL-C (r=0.371, p=0.043) and a significantly negative correlation between HOMA-IR in the control group (r=-0.682, p=0.000).

Table 3. Correlations between demographic characteristics and Ocular measurements in obese and control groups.

		Obese Grup (n=55)				Control Grup (n=30)			
		IOP	CCT	ACD	LT	IOP	CCT	ACD	LT
Age	r	-.030	-.176	.023	-0.14	.260	-0.23	-.062	-.329
	P	.831	.197	.866	0.31	.166	0.09	.744	.076
BMI	r	.071	-.034	-.058	-0.20	**.389**	-0.01	.009	**-.633**
	P	.606	.804	.674	0.15	**.034**	0.94	.961	**.000**
WC	r	.044	-.093	.028	-0.25	**.497**	-0.16	-.193	**-.749**
	P	.749	.500	.839	0.07	**.005**	0.24	.307	**.000**
Systolic BP	r	.181	-.020	.041	-0.08	-.165	-0.01	-.241	-.315
	P	.186	.882	.765	0.58	.385	0.95	.200	.090
Diastolic BP	r	.150	-.127	-.007	-0.21	-.202	**-0.27**	-.163	.114
	P	.275	.356	.962	0.13	.285	**0.04**	.389	.547
FBG	r	.204	-.103	-.029	-0.11	-.131	-0.08	-.197	.122
	P	.135	.455	.833	0.44	.491	0.55	.297	.519
TG	r	**.276**	-.033	-.048	0.11	-.054	-0.16	.064	.016
	P	**.042**	.813	.728	0.43	.775	0.24	.735	.932
TC	r	.058	.030	.161	0.03	**-.511**	-0.04	.307	-.023
	P	.674	.826	.239	0.81	**.004**	0.78	.099	.905
HDL-C	r	**-.273**	.141	-.100	0.01	-.310	0.25	-.156	-.153
	P	**.043**	.306	.469	0.97	.096	0.07	.412	.420
LDL-C	r	.028	-.066	.194	0.04	-.329	-0.01	**.371**	-.220
	P	.839	.631	.157	0.77	.076	0.92	**.043**	.242
HOMA-IR	r	.125	-.122	.015	0.02	**.384**	-0.09	**-.682**	-.066
	P	.364	.375	.914	0.90	**.036**	0.51	**.000**	.729
Insulin	r	.134	-.132	.072	0.02	**.407**	-0.07	-.188	.088
	P	.331	.336	.603	0.88	**.026**	0.59	.320	.642

Abbreviations: N,number; BMI, body mass index (kg/m2); WC, waist circumference (in cm); SBP, systolic blood pressure (mmHg); DBP, diastolic blood pressure (mmHg); FBG, fasting blood glucose (mg/dl); TG, triglycerides (mg/dl); TC, total cholesterol (mg/dl); HDL-C, high density lipoprotein- cholesterol (mg/dl); LDL-C, low density lipoprotein- cholesterol (mg/dl); HOMA-IR, Homeostatic Model Assessment for Insulin Resistance; Insulin, µIU/ml.

DISCUSSION

This study aimed to evaluate the effects of obesity and related metabolic changes on anterior segment parameters, intraocular pressure (IOP), and anterior chamber depth (ACD). No significant differences were found in IOP and ACD between the groups ($p>0.05$). However, significantly higher central corneal thickness (CCT) and lens thickness (LT) measurements were observed in the childhood obesity group compared to the healthy children. As expected, fasting blood glucose (FBG), total cholesterol (TC), triglyceride (TG), low-density lipoprotein-cholesterol (LDL-C), homeostatic model assessment of insulin resistance (HOMA-IR), and insulin levels were significantly higher in the obese group.

Furthermore, there was a significant negative correlation between body mass index (BMI) and waist circumference (WC) with LT in the control group only. In the obese group, there was a significant positive correlation between IOP and TG, and a significant positive correlation was found between IOP and BMI, WC, HOMA-IR, and insulin in the control group. Additionally, a significant negative correlation was found between IOP and TC in the control group. However, no significant correlations were observed between anthropometric and metabolic characteristics and CCT or ACD in the obese group. In the control group, there was a significantly positive correlation between ACD and LDL-C, and a significantly negative correlation between ACD and HOMA-IR.

Previous studies have examined the relationship between obesity and IOP. Akıncı et al. found that obesity is a risk factor for increased IOP in pediatric patients (10). Baran et al. reported elevated IOP in obese children in a study involving 61 obese patients and 35 healthy control subjects (11). Pekel et al. reported similar IOP measurements in obese and non-obese children (12). Kocak et al. compared IOP values between obese and normal-weight children and found no significant difference in IOP values, visual field examinations, and cup/disc ratios between the two groups (5).

Obesity has emerged as a significant problem not only in adults but also in children. However, the impact of obesity on intraocular pressure (IOP) in children is not yet fully understood. Several possible mechanisms have been proposed to explain the association between obesity and elevated IOP. These include the presence of excess intraorbital fat tissue, increased episcleral venous pressure, and reduced outflow, which collectively contribute to higher IOP in obese individuals (13,14). Additionally, obesity can lead to increased blood viscosity due to elevated red blood cell count, hemoglobin, and hematocrit levels, resulting in increased resistance to outflow in the episcleral vessels. Elevated arterial blood pressure also contributes to increased IOP by raising ciliary artery pressure and promoting ultrafiltration of the aqueous humor (15,16). Furthermore, obesity, particularly in the presence of insulin resistance, can contribute to increased IOP (17). Autonomic dysfunction and hyperglycemia, which are commonly associated with insulin resistance, may create an osmotic gradient leading to fluid shift into the intraocular space, thus affecting IOP.

In this study, overweight/obese children with a mean BMI of 27.17 kg/m2 were included, as children with very high BMIs often exhibit insulin resistance. Previous research has shown a connection between obesity and IOP in both adults and children (18). Cohen et al. investigated the relationship between BMI and IOP in men and women and found obesity to be a risk factor for elevated IOP in both genders (19).

The study revealed that the mean central corneal thickness (CCT) and lens thickness (LT) were significantly higher in the obese group. However, a study conducted by Güneş et al. did not find a significant difference in CCT between the two groups (20). Similarly, studies by Erol et al. and Acer et al. also reported no significant differences in CCT and anterior chamber depth (ACD) between the obese and healthy groups (21,22).

Numerous studies have found a positive association between obesity and lens thickness, although the underlying mechanism is not fully understood. It is possible that oxidative stress plays a role in the development of obesity-related diseases, including cataracts (4,22,23). Similarly, in our study, LT was found to be statistically significant and higher in the obese group. The significant differences in fasting blood glucose, HOMA-IR, and insulin levels between the obese and control groups, as well as the association between LT and CCT, may be attributed to the osmotic balance mechanisms influenced by high blood glucose levels.

Another study that investigated changes in ocular measurements related to obesity found a positive correlation between intraocular pressure (IOP) and body mass index (BMI), as well as between BMI and anterior chamber depth (ACD). The results demonstrated that the obese group had significantly higher ACD and IOP compared to the control group (24).

In our study, a significant negative correlation was observed between diastolic blood pressure (DBP) and central corneal thickness (CCT) in the control group. However, no significant relationship was found between any ocular parameter and age, systolic blood pressure (SBP), or fasting blood glucose (FBG) in both groups. However, a study by Okosun et al. showed a positive correlation between waist circumference and blood pressure and FBG, indicating that as the

BMI index increases, the likelihood of increased FBG also rises (25). Previous studies have also reported an adverse link between BMI and parameters such as anterior chamber depth (ACD) and anterior chamber angle (ACA) (7,20).

A limitation of our study was the small number of patients, as some children exhibited low cooperation during the testing process. We believe that the lack of a significant difference in IOP values between the obese and control groups in our study may be attributed to the inclusion of obese individuals with relatively low BMI, the use of non-contact tonometry for intraocular pressure measurement, and differences in systemic parameters such as SBP, FBG, and HOMA-IR. It is important to note that obesity has been associated with various ocular diseases.

In conclusion, our study found higher CCT and LT in the obese group compared to the control group. However, no significant differences were observed in IOP and ACD between the obese and control groups. Further literature studies are necessary to gain a better understanding of the relationships between ocular parameters in children with obesity and those with a normal BMI.

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