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How does being Overweight Affect the Choroid in Children?

Fazla Kilolu Olmak Çocuklarda Koroidi Nasıl Etkiler?

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ABSTRACT

Objective: The study aimed to compare the effect of overweight on choroidal thickness (CT) and choroidal vascular index (CVI) in children.

Materials and Methods: This study included forty-four overweight and obese children and 35 children with normal weight. After a complete ophthalmological examination of the participants, macula and choroidal images were taken with optical coherence tomography. The fovea's central macular thickness, subfoveal, 1000-µm nasal, and 1000-µm temporal CT were measured. Total choroidal area (TCA), luminal area (LA), and stromal area (SA) were measured using the binarization method.

Results: The mean body mass index (BMI) value of the overweight group was 27.70±1.55. The obese group was 35.73±3.84, and the control group was 21.56±1.44. Subfoveal CT, TCA, and SA values significantly differed between the groups (p=0.019, p=0.016, p=0.028, respectively). A significant positive correlation existed between BMI and subfoveal CT, TCA, and SA (r=0.264, p=0.019; r=0.233, p=0.038; r=0.231, p=0.041, respectively).

Conclusions: The obese group had significantly higher subfoveal CT, TCA, and SA values than the control group, and a significant positive correlation was found between BMI and subfoveal CT, TCA, and SA.

Keywords: Choroidal thickness, choroidal vascularity index, optical coherence tomography, overweight, pediatric obesity

ÖZ

Amaç: Bu çalışma kilo fazlalığının çocuklarda koroid kalınlığı (KT) ve koroid vasküler indeksini (KVİ) üzerine etkisini karşılaştırmayı amaçlamıştır.

Materyal ve Metot: Çalışmaya 44 fazla kilolu ve obez çocuk ile 35 normal kilolu çocuk dahil edildi. Katılımcıların tam oftalmolojik muayenesinin ardından optik koherens tomografi ile makula ve koroid görüntüleri alındı. Foveanın merkezi makula kalınlığı, subfoveal, 1000 µm nazal ve 1000 µm temporal KT ölçüldü. Toplam koroid alanı (TKA), luminal alanı (LA) ve stromal alan (SA), ikilileştirme yöntemi kullanılarak ölçüldü.

Bulgular: Aşırı kilolu grubun ortalama vücut kitle indeksi (VKİ) değeri 27,70±1.55; obez grubun ortalama VKİ değeri 35,73±3,84; kontrol grubunun ortalama VKİ değeri ise 21,56±1,44 idi. Subfoveal KT, TKA ve SA değerleri gruplar arasında anlamlı farklılık gösterdi (sırasıyla p=0,019, p=0,016, p=0,028). BMI ile subfoveal KT, TKA ve SA arasında anlamlı pozitif bir korelasyon mevcuttu (sırasıyla r=0,264, p=0,019; r=0,233, p=0,038; r=0,231, p=0,041).

Sonuç: Obez grubun subfoveal KT, TKA ve SA değerlerinin kontrol grubuna göre anlamlı derecede yüksek olduğunu gösterdi. Ayrıca VKİ ile subfoveal KT, TKA ve SA arasında anlamlı pozitif korelasyon bulundu.

Anahtar Kelimeler: Aşırı kilo, koroid kalınlığı, koroid vaskülarite indeksi, optik kohorens tomografi, pediatrik obezite

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INTRODUCTION

Obesity is a significant and growing health problem worldwide. The increase in obesity causes various childhood diseases.[1] It affects many systems, one of which is the eye. Ocular diseases such as dry eye, glaucoma, cataracts, diabetic retinopathy, and age-related macular degeneration are more common in obese individuals.[2-4] Although the reasons for this are unknown, conditions caused by obesity, such as oxidative stress and vascular damage, may cause these diseases.[5] The most vascular tissue of the eye is the choroid. The choroid supplies approximately more than two-thirds of the blood requirement of the ocular tissues. It is responsible for the nutrition of the outer retinal layers, oxygen demand, adjustment of intraocular pressure, and thermoregulation.[6,7] It can be affected by systemic diseases such as hypertension, diabetes, and endocrine in patients, as well as systemic inflammatory diseases, such as rheumatoid arthritis and systemic lupus erythematosus. The choroid can also be affected by ocular diseases such as central serous chorioretinopathy, retinitis pigmentosa, age-related macular degeneration, glaucoma, and chorioretinal inflammation.[8,9] Evaluation of the choroidal layer can result in important findings in terms of early detection and prevention of these diseases.

Advances in optical coherence tomography (OCT) and other technological developments have allowed us to examine the choroid layer. Enhanced depth imaging optic coherence tomography (EDI-OCT) enables us to evaluate the choroid layer in vivo, rapidly, non-invasively, and objectively.[10-13] Although studies on choroidal thickness (CT) in obese children exist in the literature, the results are inconsistent. A few studies have evaluated the choroidal vascular index (CVI), allowing us to assess vascular changes better.

In the current study, we aimed to compare the subfoveal and perifoveal CTs and CVIs of overweight and obese children with those of children with normal weight.

MATERIALS AND METHODS

Ethics Committee Approval: This was a retrospective study that was conducted in the pediatric endocrine and ophthalmology departments of XX University’s Erol Olçok Training and Research Hospital. Approval was obtained from the ethics committee of XX University (date: 2022, decision no:109). The study was carried out in accordance with the Helsinki Declaration. Oral and written consent forms were obtained from the participating children and their parents.

Subjects: Forty-four children with a body mass index (BMI) of 25 and above and 35 healthy children with a normal BMI were included in the study. Individuals with strabismus and a history of ocular surgery, who use systemic and topical drugs, who suffer from systemic disease (diabetes, hypertension, heart disease), who have spherical equivalent (SE) values of ±3 diopters (D) and above or intraocular pressure (IOP) >21 mmHg, participants with ocular diseases such as amblyopia, uveitis, cataract, glaucoma, vitreous, and retinal disorders, and who wear contact lens were excluded in the study.

The weight and height of the children with a BMI of 25 or more who were seen in the paediatric endocrinology department were measured and recorded. Weight and height measurements were made with a digital automatic height weight scale without shoes and with light clothes (Densi GL-150, Industrial Weighing Systems). BMI was calculated using the kg/m2 formula. Those with a BMI of 25–29.9 kg/m2 were considered overweight, and those with a weight of 30 and above were considered obese. The control group consisted of 35 healthy children examined in the ophthalmology clinic with a BMI within normal limits (20–24.9). BMI standard deviation score (BMI SDS) reference values determined for Turkish children were used.[14]

Measurements: Refraction and IOP measurements were performed on the participants with an autorefractometer and an integrated non-contact tonometry device (Topcon Corporation, Tokyo, Japan). The best corrected visual acuities were measured using Snellen's chart. Those with vision worse than 10/10 were excluded from the study. Anterior segment examinations were performed with a slit lamp. The optic nerve and macula were evaluated by performing posterior segment examinations without dilation with a +90 D lens. Axial lengths were obtained with an optical biometry device (AL-Scan; Nidek Co., Ltd). The central macula and choroidal layer with EDI mode were obtained with a Spectralis OCT device (Spectralis, Heidelberg Engineering, Heidelberg, Germany). Measurements were subsequently taken. For CT, the section from the retinal pigment epithelium to the inner layer of the sclera was measured. These measurements were recorded subfoveal, 1000-micron nasal, and temporal to the fovea. The images of the choroidal tissue were transferred to the ImageJ program (National Institutes of Health, Bethesda, USA) in B-scan mode (Figure 1).

Binarization: Total choroidal area (TCA) and luminal area (LA) were calculated as described by Agrawal et al.[15] A subfoveal scan (central B-scan) was selected for CVI calculation. Images were transferred to the ImageJ programme (National Institutes of Health, Bethesda, MD, USA). After the TCA was selected, a region of interest (ROI) manager was added. The image was 8-bit inverted using Niblack

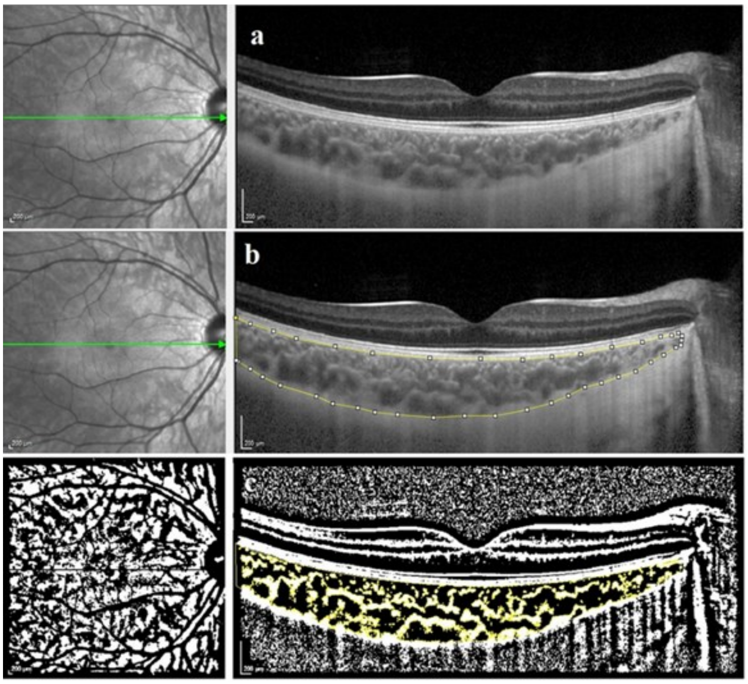

Figure 1. a) EDI-OCT imaging of the subfoveal choroidal layer, b) Image of marking the total choroidal area, c) Determination of luminal and stromal areas using the color threshold tool.

auto local thresholding. Colour thresholding was used to highlight luminal areas. The LA was transferred to the ROI manager. TCA and LA merged by 'AND', selected in the ROI manager and added a third field to the ROI manager. The first field in the ROI manager was calculated as TCA, and the third field was calculated as LA. Stromal area (SA) was calculated as the difference between TCA and LA, and CVI was calculated as the LA/TCA ratio. LA/SA was calculated by dividing the LA by the SA. Measurements were performed in a blinded fashion by two independent observers (SC, MD). Measurements were made between 10–12 am to avoid the effects of diurnal variation. Measurements of each participant's right eye were used in the study.

Statistical analysis: The obtained data were evaluated using SPSS 22.0 (SPSS, Inc., Chicago, IL, USA). The conformity of the data to the normal distribution was evaluated with the Kolmogorov–Smirnov test. An ANOVA test was used for those with normal distribution in triple comparisons, and Tukey's test was used for post hoc analysis. A Kruskal-Wallis test was used for those not normally distributed; pairwise comparisons were made using the Mann–Whitney U test and evaluated using Bonferroni correction. Correlation analysis was performed using Spearman correlation analysis. Data were given with mean and standard deviation (mean±SD) values; p <0.05 was considered significant.

RESULTS

A total of 79 individuals—27 males and 52 females—were included in the study. The overweight group consisted of eight males (30.8%) and 18 females (69.2%); the obese group consisted of eight males (44.4%) and ten females (55.6%), and the control group consisted of 11 males (31, 4%), 24 females (68.6%). In terms of gender, there was no significant difference between the groups (p=0.984). The mean age of the overweight group was 12.04±2.81; the mean age of the obese group was 14.06±1.92; and the mean age of the control group was 12.29±3.75. There was no significant age difference between the groups (p=0.096). Height, weight, BMI, BMI SDS, SE, IOP, AL, and CMT values are shown in Table 1. There was a significant difference between the groups in terms of weight, BMI, and BMI SDS (for all, p<0.001).

A statistically significant difference was detected between the groups in terms of subfoveal CT (p=0.019). In the evaluation of choroidal structures, there was a significant difference between the groups in terms of TCA and SA (p=0.016, p=0.028, respectively). There was no significant difference between the groups in terms of LA/SA and CVI (p=0.270, p=0.279, respectively) (Table 2).

Table 1. Demographic characteristics, SE, IOP, AL and CMT of groups.

Demographic Characters	Overweight (n=26)	Obese (n=18)	Control (n=35)	p
Age (year), mean±SD	12.4±2.81	14.06±1.92	12.29±3.75	0.096*
Gender, m/f	8/18	8/10	11/24	0.984***
Height, cm, mean±SD	154.14±16.37	163.17±8.77	152.09±18.72	0.064*
Weight, kg, mean±SD	66.74±14.73	98.97±14.39	50.51±12.54	**0.001****
BMI, kg/m, mean±SD	27.70±1.55	35.73±3.84	21.56±1.44	**0.001***
BMI SDS, mean±SD	1.62±0.30	2.46±0.31	0.51±0.33	**0.001****
SE, D, mean±SD	-0.59±1.02	-0.60±0.77	-0.56±1.31	0.831*
IOP, mmHg, mean±SD	14.23±3.46	14.77±3.98	14.71±3.30	0.791*
AL, mm, mean±SD	23.48±0.95	23.49±0.74	23.58±0.99	0.900**
CMT, µm, mean±SD	264.73±18.38	253.00±20.34	264.94±15.25	0.047**

BMI: Body mass index; BMI SDS: BMI standard deviation score; SE: Spherical equivalent; D: Diopter; IOP: Intraocular pressure; AL: Axial length; CMT: Central macular thickness; *: Kruskal Wallis test; **: ANOVA test; ***: Chi-square test; bold: p<0.05.

Table 2. Comparison of CT, choroidal areas and CVI of groups.

	Overweight	Obese	Control	p
Temporal CT, µm, mean±SD	349.04±60.68	368.94±70.31	323.46±79.48	0.084*
Subfoveal CT, µm, mean±SD	350.35±57.88	386.78±71.79	324.00±86.85	**0.019***
Nasal CT, µm, mean±SD	314.04±65.47	343.44±83.77	295.91±86.45	0.126*
TCA, mm^2, mean±SD	0.54±0.09	0.60±0.12	0.51±0.12	**0.016***
LA, mm^2, mean±SD	0.35±0.06	0.40±0.09	0.33±0.09	0.058**
SA, mm^2, mean±SD	0.19±0.04	0.20±0.04	0.17±0.04	**0.028****
LA/SA, %, mean±SD	1.85±0.24	1.95±0.28	1.95±0.25	0.270**
CVI, %, mean±SD	0.65±0.03	0.66±0.03	0.66±0.03	0.279**

CT: Choroidal thickness; TCA: Total choroidal area; LA: Luminal area; SA: Stromal area; CVI: Choroidal vascular index; *: ANOVA test; **: Kruskal Wallis test; bold: p<0.05.

The correlation analysis showed a positive correlation between weight and subfoveal CT (r=0.239, p=0.034). There was a significant positive correlation between BMI and subfoveal CT, TCA, and SA (r=0.264, p=0.019; r=0.233, p=0.038; r=0.231, p=0.041, respectively). Figure 2 shows a correlation plot of subfoveal CT, TCA, and SA with BMI (Figure 2). There was a significant difference between the obese and control groups in the post hoc analysis of subfoveal CT, TCA and SA values (p=0.014, p=0.012, p=0.012, respectively).

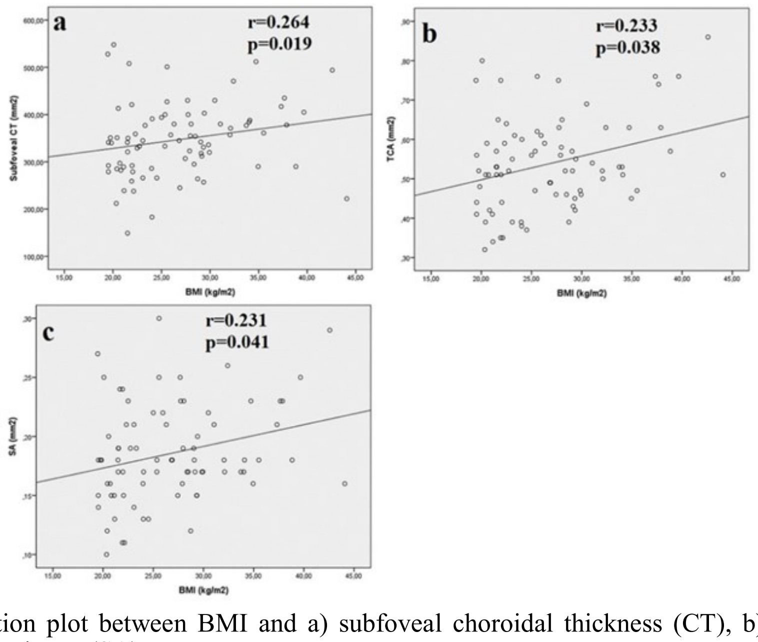

Figure 2. Correlation plot between BMI and a) subfoveal choroidal thickness (CT), b) total choroidal area (TCA), and c) stromal area (SA).

DISCUSSION AND CONCLUSION

We found that the overweight and obese group had higher CT and choroidal area values than the control group. Only the subfoveal CT, TCA, and SA values were significantly higher in the obese participants than in the control participants. There was no significant difference between the groups in terms of CVI.

Mean subfoveal CT values in healthy children were different in other related studies. The CT value was 267 µm in the study of Xiong et al.,[16] 319.44 µm in the study of Kara et al.,[17] and 248.91 µm in the study of Yao et al.[18] In our study, the subfoveal CT values of the control group were found to be 324 µm, similar to results of Kara et al.[17] It has been shown that CT is affected by many factors, such as refraction, age, and axial length.[19,20] In addition to these factors, some studies have shown that BMI affects CT. Teberik et al.[21] found CT values in the morbidly obese group to be significantly thinner in their study conducted with 101 morbidly obese (BMI ≥ 40) adults and 95 adults with normal BMI. Ozen et al.[12] found CT to be significantly thinner in the obese group in their study with 38 obese and 40 control children. Baran et al.[22] reported that there was no difference in CT between the obese participants and the control participants. In our study, unlike the previously mentioned ones, CT was thicker in the obese group. Differences may exist because CT is affected by many ocular and systemic changes. The presence of other systemic diseases in addition to obesity in the adult age group and the longer duration of obesity in adults may have caused the thinning of the choroidal layer. The pediatric patients in our study group did not have any other systemic diseases, and the duration of obesity was shorter than in adults. Different results may also be due to the different OCT devices used.

Contrary to the previously mentioned studies, Gonul et al. evaluated 40 morbidly obese patients scheduled for bariatric surgery and found that CT was thicker in the obese group. The authors showed that after surgery, the CT thinned with a decrease in BMI. They stated this might be due to venous congestion in obese patients.[23] Bulus et al.[24] found subfoveal CT at a range of 385.77±69.09 µm in the obese group and 348.77±73.21 µm in the control group in their study with 44 obese and 42 healthy children. Subfoveal CT, nasal CT, and temporal CT measurements were also found to be higher in the obese participants significantly by Bulus et al.[24] In our study, temporal, subfoveal, and nasal CT were at higher values in the overweight and obese participants than in the control group. There was only a significant difference between the obese and the control participants in subfoveal CT. Unlike our study, the abovementioned studies did not evaluate choroidal areas and CVI.

Although CT is an important parameter that provides information about the choroid, it cannot distinguish between vascular and stromal changes. As a result of the evaluation of OCT images using the binarization method, the vascular and stromal values of the choroid can be calculated and used separately. The CVI, defined by Agrawal et al.,[9] is obtained using the ratio of LA to TCA. This parameter can be used as a helpful marker in many ocular diseases.[25,26] In this study, the values of the overweight and obese participants in terms of CVI were similar to the control participants. TCA, LA, and SA values were higher in the overweight and obese groups compared to the control group. However, in the analysis of TCA and SA, a significant difference was detected. This difference demonstrates that the increase in LA lags behind the increase in SA and TCA. Obesity-related vasodilation and vasoconstriction imbalance may occur with vascular tissues. It has been reported that the nitric oxide level, which provides vasodilation, decreases in obese individuals, and vasoconstrictor molecules such as endothelin-1 and angiotensin-2 increase.[27,28] This may be a reason why LA lags behind the increase in tissue.

There are some limitations in the current study. The first is that the number of participants is relatively small, so these data need to be confirmed with larger patient groups. Second, this is a cross-sectional study. Long follow-up studies are needed to understand how changes in the choroid lead to changes in both the choroid and the retina in the future. Thirdly, investigating the changes in CT in overweight individuals after weight loss may provide more accurate results about the relationship between BMI and CT.

The strength of our study is that it is one of the few that evaluate both overweight and obese children during childhood; it is also the first study to evaluate CVI.

In conclusion, this study showed that obese children had significantly higher subfoveal CT, TCA, and SA values. On the other hand, there was no significant difference between the groups in terms of CVI. There was a significant positive correlation between BMI and subfoveal CT, TCA, and SA. Studies with a large population and long follow-ups are needed to evaluate the ocular changes caused by the increase in CT caused by being overweight.

Ethics Committee Approval: Our study was approved by the Ethics Committee of XX University (Date: 28.12.2022- decision no: 109). The study was carried out in accordance with the international declaration, guidelines, etc.

Conflict of Interest: No conflict of interest was declared by the authors.

Author Contributions: Concept – MD, SC; Supervi-

sion – MD, SC, FE; Materials – MD, SC, FE; Data Collection and/or Processing – MD, SC, FE; Analysis and/ or Interpretation – MD, SC, FE; Writing – MD.

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