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ORIGINAL ARTICLE

Comparison of retinal nerve fiber layer thickness between malnourished and healthy children using spectral domain optical coherence tomography.

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ABSTRACT… Objective: To compare the retinal nerve fiber layer (RNFL) thickness between malnourished and healthy children using Spectral Domain Optical Coherence Tomography (SD-OCT). **Study Design:** Cross-sectional study. **Setting:** Department of Pediatrics, National Institute of Child Health and The Hashmani's Hospital, Karachi, Pakistan. **Period:** January 2023 to June 2023. **Methods:** Twenty-two malnourished children of either gender, aged between 5-12 years, with no ocular findings, and another 22 healthy children of either gender with relatively similar age, with no ocular findings were enrolled. Anthropometric measurements including height and weight were performed and Z-score were calculated. All participants underwent a comprehensive eye examination. The SD-OCT was employed to record thickness of the RNFL. **Results:** In a total of 44 children, there were 22 (50.0%) boys and 22 (50.0%) girls. The mean age was 9.30±2.93 years (ranging between 5 to 12 years). The mean BMI Z-score was -1.01±2.11. Intraocular pressure was significantly reduced in children with malnutrition ($p<0.001$). Children with malnutrition were having significantly decreased superonasal (110.27±19.26 vs. 125.32±17.49, $p=0.010$), and infernonasal (112.86±21.04 vs. 132.00±31.53, $p=0.023$) RNFL. Correlation of body mass index (BMI) Z-Scores with parameters of RNFL thickness showed a significantly positive relationship with global scores ($p=0.031$). **Conclusion:** Our study using SD-OCT revealed that malnourished children exhibited decreased thickness of RNFL compared to healthy children. Furthermore, there was a positive relationship between BMI Z-scores and global RNFL thickness scores.

Key words: Body Mass Index, Intraocular Pressure, Malnutrition, Optical Coherence Tomography, Retinal Nerve Fiber Layer.

INTRODUCTION

In the recent decades, understanding the potential impact of nutritional status on various aspects of health, including ocular health has gained popularity. Despite the World Health Organization's effective efforts to combat hunger in recent times, malnutrition continues to represent a significant public health challenge.[1] Malnutrition, characterized as a state where there exists an inequilibrium between the intake of nutrients and the body's requirements, resulting in the accumulation of deficits in energy, protein, or micronutrients, has the potential to adversely impact growth, development, and other pertinent outcomes.[2]

The "retinal nerve fiber layer (RNFL)" is a crucial component of the retina and considered pivotal in transmitting visual information from eye to brain. "Spectral domain optical coherence tomography (SD-OCT)" functions as a fundamental instrument for the identification of diverse ocular conditions due to its notable consistency in results and diagnostic precisions.[3] OCT scans the retina producing visual representation of the intricate three-dimensional arrangement of the retina and its nerve fiber layers.[4] Our existing understanding of the impacts of malnutrition on ocular health pertains primarily to conditions linked with micronutrient deficiencies such as deficiencies of vitamin A causing visual impairment, keratitis, reduced dark adaptation, xerophthalmia and diminished macular thickness.[5] Other ocular disorders associated with insufficiencies in other

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micronutrients involve ocular surface impairment as a result of riboflavin deficiency, nystagmus related to thiamine deficiency, optic atrophy stemming from copper or B12 deficiencies, occurrences of strabismus, macular degeneration, thinning of the RNFL, and reduction in the thickness of this layer due to iron deficiency.[6,7]

According to a study, malnutrition reportedly leads to cortical thinning, reduced neuron count and myelination.[8] To examine the effect of malnutrition on choroid, SD-OCT can be used to observe the vascular structure supplying micronutrients and oxygen to the outer retina. To the best of our knowledge, very few studies are on view comparing the RNFL thickness in malnourished and healthy children using SD-OCT.[9] Moreover, no local data exists regarding the impact of malnutrition on RNFL thickness. This study was aimed at comparing the RNFL thickness between malnourished and healthy children using SD-OCT.

METHODS

This case-control study was conducted at Department of Pediatrics, "National Institute of Child Health (NICH)" and The Hashmani's Hospital, Karachi, from January 2023 to June 2023 after approval from both study centers. Informed and written consents were obtained from parents or legal guardians before participation of their child in this study. This was approved by ethical committee (IERB-17/2021, Dated:02.03.2022).

Twenty-two malnourished children of either gender, aged between 5-12 years, with no ocular findings were analyzed in this study. Another 22 healthy children of either gender with relatively similar age, with no ocular findings were enrolled as controls. Exclusion criteria were children using steroids, appetizers, or enteral feed in the past 3 months. Children with congenital heart defects, celiac disease, type 1 diabetes, renal failure, cerebral palsy, genetic disorders, or growth hormone disorders were also not included. Children with non-malnutrition cause of stunting, such as constitutional short stature, or chronic renal disease, or chronic liver disease were also excluded. Ophthalmological causes of exclusion were a history of glaucoma, keratoconus, ocular trauma or surgery, amblyopia, uveitis, strabismus, or vascular abnormalities. Patients with myopic, hypermetropic, or astigmatic refractive errors > +2.0 D and < -4.0 D were also not included.

Anthropometric measurements including height and weight were performed and Z-score calculated of all patients admitted to the in-patient department. Malnutrition was labeled as Z-scores < -2 for weight for age and/or BMI for age. Slit-lamp biomicroscopy, measurement of intraocular pressure, evaluation of refractive error, determination of visual acuity, and a detailed examination of the dilated fundus were performed. The best recorded visual acuity values for each patient were documented, utilizing the Snellen chart with decimal fractions. To visualize the RNFL and the choroid, SD-OCT "(Spectralis; Heidelberg Engineering, Heidelberg, Germany)" was employed without the need for pupil dilation and adopting standard protocols.

Data was analyzed through "IBM-SPSS Statistics", version 26.0. The Pearson correlation was used to correlate RNFL thickness and BMI Z-scores. Independent sample t-test was employed to compare data between both study groups taking $p<0.05$ as significant.

RESULTS

In a total of 44 children, there were 22 (50.0%) boys and 22 (50.0%) girls. The mean age was 9.30±2.93 years (ranging between 5 to 12 years). The mean height and weight were 133.98±24.84 cm and 32.39±17.51 kg respectively. The mean BMI Z-score was -1.01±2.11. Intraocular pressure was significantly reduced in children with malnutrition ($p<0.001$) (Table-I).

Children with malnutrition were having significantly decreased superonasal (110.27±19.26 vs. 125.32±17.49, $p=0.010$), and infernonasal (112.86±21.04 vs. 132.00±31.53, $p=0.023$) RNFL, while all other parameters did not show any significant differences ($p>0.05$) as shown in Table-II.

Characteristics		Malnutrition (n=22)	Healthy (n=22)	P-Value
Gender	Boys	12 (54.5%)	10 (45.5%)	0.546
	Girls	10 (45.5%)	12 (54.5%)	
Age in years	5-8	6 (27.3%)	10 (45.5%)	0.210
	9-12	16 (72.7%)	12 (54.5%)	
Age in years (Mean±SD)		9.86±2.49	8.73±3.33	0.207
BMI Z-Score		0.90±0.39	-2.92±1.16	<0.001
Visual Acuity		0.95±0.09	1±0	0.008
Refractive error		-2.23±1.72	0.18±1.30	<0.001
IOP		10.98±1.78	10.46±2.26	0.399

Table-I. Demographic and ocular characteristics in both study groups (n=44)

Retinal Nerve Fiber Layers	Malnutrition (n=22)	Healthy (n=22)	P-Value
Global	99.55±8.80	104.27±8.02	0.070
Superonasal	110.27±19.26	125.32±17.49	0.010
Superotemporal	140.32±17.20	135.05±21.36	0.372
Temporal	73.09±9.88	74.86±8.97	0.537
Nasal	76.14±13.42	80.45±13.41	0.292
Inferonasal	112.86±21.04	132.00±31.53	0.023
Inferotemporal	134.41±16.83	131.27±21.85	0.594

Table-II. Comparison of RNFL thickness parameters in both study groups

Correlation of BMI Z-Scores with parameters of RNFL thickness showed a significantly positive relationship with global scores (p=0.031). Although, most other parameters showed a weak but positive correlation (except for superonasal), but the statistically significant correlations were not observed (p>0.05), as shown in Table-III.

Retinal Nerve Fiber Layers	Correlation Coefficient	P-Value
Global	0.430	0.046
Superonasal	-0.046	0.837
Superotemporal	0.391	0.072
Temporal	0.256	0.250
Nasal	0.339	0.123
Inferonasal	0.295	0.183
Inferotemporal	0.286	0.196

Table-III. Correlation of BMI Z-Scores with RNFL Thickness (n=44)

Pearson Correlation applied

DISCUSSION

Malnutrition is a critical global health issue, particularly affecting children, and its systemic impact on various organ systems, including the eyes, has been recognized.[5-7] Our results revealed reduced RNFL thickness in malnourished children when compared to healthy children. These observations suggest that malnutrition may be linked with alterations in the structural integrity of the RNFL. The positive relationship observed between BMI Z-scores and RNFL thickness in our study suggested that lower BMI Z-scores may correlate with retinal alterations, possibly due to nutritional deficiencies. Our results align with a study conducted by Gungor S et al in Turkey, which demonstrated that as the degree of malnutrition increased, there was a notable increase in thinning of the peripapillary RNFL, particularly in the temporal segment (with correlation coefficients of -0.249 and -0.251, and p-values of 0.003 and 0.002, respectively).[10] A study done by Baran RT et al documented the impact of obesity on ophthalmological parameters and found that there existed a negative correlation between the mean RNFL and BMI SD scores (p=0.044).[11] Some other researcher have shown the impact of vitamin B12 deficiency on RNFL thickness as well.[12] A recent in vivo study by Yesilkaya et al exhibited that The childhood undernutrition and overnutrition may affect the density of retinal capillaries.[13] Malnutrition can lead to deficiencies in essential nutrients, including vitamins and minerals, which are vital for maintaining the integrity of retinal structures. Deficiencies in nutrients like vitamin A, omega-3 fatty acids, and antioxidants can affect retinal health and potentially lead to thinner RNFL as a compensatory response or as part of the pathological changes associated with nutrient deficiencies. Altered blood flow and microvascular changes can contribute to decreased RNFL thickening, possibly as an adaptive response to compromised circulation.[14] The observed alterations in RNFL thickness among malnourished children have important clinical implications. These structural changes may be indicative of early retinal pathology and warrant further investigation. Routine ophthalmic assessments, including SD-OCT, could serve as valuable tools for monitoring the ocular health of malnourished children and facilitating early intervention.

Not many studies addressing macular or RNFL thickness in cases of pediatric malnutrition can be found in the existing literature. However, earlier research on obese pediatric cases has indicated an altered reduction in RNFL values when compared to their healthy counterparts.[15,16] In contrast, a separate study observed a statistically non-significant reduction in RNFL values in obese children. Nevertheless, this indicates an unfavorable correlation between the BMI Z-score and RNFL thickness.[17] A previous investigation involving adult patients with anorexia nervosa did uncover statistically significant reductions in both macular thickness and RNFL thickness when compared to individuals without the condition.[18]

The prevalence of RNFL thinning in malnourished children may vary across populations and settings. Potential confounding factors, such as micronutrient deficiencies and other systemic comorbidities, were not comprehensively addressed in this study and should be explored in future research.

CONCLUSION

Our study using SD-OCT revealed that malnourished children exhibited decreased thickness of RNFL compared to healthy children. Furthermore, there was a positive relationship between BMI Z-scores and global RNFL thickness scores. These findings suggest a potential association between malnutrition and alterations in retinal health in children. Further research is needed to explore the clinical implications and longitudinal effects of these observations.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

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1	Hina Rajani	Data collection, Drafting.	
2	Misbah Anjum	Critical revisions, Proof reading.	