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REVIEW ARTICLE

Normative data for optical coherence tomography in children: a systematic review

Ana Banc[1] · Marius I. Ungureanu[2]

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Abstract

The purpose of this study is to systematically review the reported data of normal optical coherence tomography (OCT) results in the paediatric population. A systematic literature search was performed using the PubMed, Embase, and Web of Science databases, using the keywords "optical coherence tomography"; "normative data" or "healthy eyes"; "children" or "paediatric population". Studies with at least 50 participants were included, irrespective of the OCT equipment employed. We excluded the OCT angiography studies or the studies investigating the choroidal thickness. Seventy-four studies were included in the final analysis and information on study design, number of participants, demographic characteristics, type of OCT equipment, OCT parameters and results was collected. Due to the high variability of OCT instruments and parameters used, a meta-analysis was not feasible. We report the normative values for the peripapillary retinal nerve fibre layer thickness and the macular retinal thickness for each ETDRS quadrant, as provided by the studies included in the present analysis. We also report the influence of ethnicity, age, gender, eye laterality, ISNT rule, spherical equivalent, and axial length on OCT results.

Introduction

Optical coherence tomography (OCT) is a non-invasive and non-contact imaging technique, which found its applicability in various ocular conditions affecting either the anterior segment of the eye or the optic nerve and the retina. Due to the high speed of scanning, the OCT assessment can also be performed in patients who present certain difficulties in collaboration, including children. Despite of the challenges of OCT use in the paediatric population (e.g., height and position of the headrest, size of the machine, image artifacts produced by small movements, etc.), there are numerous papers reporting the OCT evaluation in children with optic nerve swelling, glaucoma, retinal dystrophies, and other [1], with high repeatability and reproducibility indices for the OCT use in this young population [2].

Several OCT instruments produced by different manufacturers are available, but the equipment has an incorporated age-matched normative database only for adults. This is the reason why the quantitative interpretation of results obtained in children is difficult.

Some authors suggested to use the follow-up method, which consists in setting the first examination as a reference, and all the other examinations would be compared to the first [3]. However, the sequential analysis of a growing eye during larger periods of time could be potentially influenced by the changing values of the examined parameters given by the growth itself.

Other researchers examined the OCT features in normal children and many papers showing these results have already been published. In order to help the clinicians to find the relevant study for their practice, the purpose of our paper is to review the literature on the normative data for OCT parameters in the paediatric population.

Methods

A systematic literature review was conducted using the PubMed, Embase, and Web of Science databases. The search was performed independently by both authors

✉ Ana Banc
ana.banc@umfcluj.ro

[1] Department of Ophthalmology, Iuliu Hatieganu University of Medicine and Pharmacy, Cluj-Napoca, Romania

[2] Department of Public Health, Babeș-Bolyai University, Cluj-Napoca, Romania

according to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [4]. We restricted the search to articles published in English and the following MeSH terms (Medical Subject Headings) were used: "optical coherence tomography", "normative database" OR "healthy eyes", "children" OR "paediatric population". We did not use any restriction for the publication date.

The inclusion criteria were: original studies conducted on human participants aged <18, no ocular disease other than refractive errors, use of posterior pole OCT, and at least 50 participants enroled in the study.

We excluded review articles and the papers in which adult participants were also included or the patients had a systemic disease which can induce retinal or optic nerve alterations (e.g., diabetes). We did not include in the present review the research on OCT angiography or the studies which had the objective to evaluate the thickness of the choroid. Inconsistency in statistical report was another reason for exclusion. We also excluded the studies which investigated solely the reproducibility of the OCT examination in children.

All the records were screened for relevancy based on title and abstract, and the relevant articles were included in the full-text evaluation. The above-mentioned inclusion and exclusion criteria were the only criteria used to determine the eligibility of each study. The differences between the lists of eligible studies were discussed by the two authors. We also performed a manual search of the list of references of the included articles in order to identify additional published studies not indexed in the three databases.

We did not use the type of OCT equipment as an indicator for the selection of articles, and we have no conflict of interest for this research. The date of our last search was June 17, 2020.

In order to perform the quality assessment for the included studies, we employed the Joanna Briggs Institute Critical appraisal tool for case series [5]. From each study included into evaluation, we collected information on study design, number of participants, demographic characteristics, type of OCT equipment, and OCT parameters.

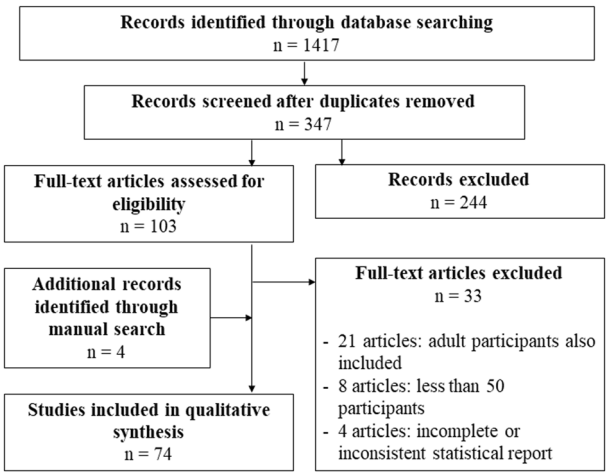

Fig. 1 Flow diagram indicating the review process. Records identified through searching of 3 databases were screened based on title and abstract; after duplicates were removed, the full-text version of 103 articles was assessed for eligibility. Four additional papers were found by searching the lists of references of the eligible articles. After the exclusion of 33 articles which did not meet the inclusion criteria, 74 studies were included in the present review.

Results

The review process

The PubMed database search provided 581 records, Embase provided 562 records, and Web of Science 274 records. After screening and full-text assessment, 74 articles were included into the analysis (Fig. 1).

In Table 1, we provide the results of the quality assessment of the studies included in our systematic review. The Joanna Briggs Institute checklist [5] contains 10 items assessing the selection bias (item 1), performance bias (items 2 and 3), design bias (items 4, 5, and 10), and reporting bias (items 6–9). All these items are found in Table 1. For item 2, we considered the standardised ophthalmological examination which had concluded that the selected eyes were normal, whereas for item 3 we assessed the OCT scanning protocol of the included eyes. Regarding the reporting of the demographics of the participants in the study (item 6), we took into consideration age, gender, and ethnicity. For item 7, we evaluated the reporting of the ophthalmological evaluation results, and for item 8 we assessed the reporting of OCT results.

The records in Table 1 are sorted by OCT technology, alphabetically by OCT manufacturer, and then chronologically by the publication date; this order is respected throughout the "Results" section.

Collected data

In Table 2 are found the demographic and clinical features of the papers included in the present review. Twenty-two studies were conducted using the time domain OCT technology, whereas 52 studies employed spectral domain OCT devices. Twenty-four studies were population based, whereas the other were hospital based. The vast majority of the studies included children older than 3 and the OCT evaluation was performed at a table-mounted instrument; four papers used a handheld OCT device to examine neonates or very young children [6–9].

Table 1 Quality assessment of studies included in the systematic review, according to Joanna Briggs Institute Critical appraisal checklists for case series [5].

Authors and year	1. Were there clear criteria for inclusion in the case series?	2. Was the condition measured in a standard, reliable way for all participants included in the case series?	3. Were valid methods used for the identification of the condition for all participants included in the case series?	4. Did the case series have consecutive inclusion of participants?	5. Did the case series have complete inclusion of participants?	6. Was there clear reporting of the demographics of the participants in the study?	7. Was there clear reporting of clinical information of the participants?	8. Were the outcomes of cases clearly reported?	9. Was there clear reporting of the presenting site(s)/ clinic(s) demographic information?	10. Was statistical analysis appropriate?
Time domain OCT										
Ahn et al. [20]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Salchow et al. [45]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Huynh et al. [12]	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Huynh et al. [11]	Yes	Unclear	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes
Luo et al. [79]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Huynh et al. [13]	Yes	Unclear	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes
Samarawickrama et al. [78]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Jun and Lee [76]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Huynh et al. [50]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
El-Dairi et al. [14]	Yes	Yes	Yes	Unclear	Unclear	Yes	Unclear	Yes	Yes	Yes
Eriksson et al. [36]	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes
Samarawickrama et al. [85]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Leung et al. [21]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Tariq et al. [15]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Samarawickrama et al. [16]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Larsson et al. [22]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Zhang et al. [37]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Tariq et al. [86]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Qian et al. [69]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Tas et al. [58]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	No	Yes
Pawar et al. [23]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Hong et al. [47]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	No	Yes
Spectral domain OCT										
Allingham et al. [6]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Rothman et al. [7]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Patel et al. [8]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Lim et al. [9]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Elia et al. [24]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes
Barrio-Barrio et al. [25]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Rao et al. [26]	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes
Altemir et al. [70]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes
Katiyar et al. [51]	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Oner et al. [81]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	No	Yes
Al-Haddad et al. [67]	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Galdos et al. [52]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Unclear	Yes

Table 1 (continued)

Authors and year	1. Were there clear criteria for inclusion in the case series?	2. Was the condition measured in a standard, reliable way for all participants included in the case series?	3. Were valid methods used for the identification of the condition for all participants included in the case series?	4. Did the case series have consecutive inclusion of participants?	5. Did the case series have complete inclusion of participants?	6. Was there clear reporting of the demographics of the participants in the study?	7. Was there clear reporting of clinical information of the participants?	8. Were the outcomes of cases clearly reported?	9. Was there clear reporting of the presenting site(s)/ clinic(s) demographic information?	10. Was statistical analysis appropriate?
Al-Haddad et al. [27]	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Chen et al. [61]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Queiros et al. [28]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Molnar et al. [38]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Totan et al. [53]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Sushil et al. [39]	Yes	Yes	Yes	Unclear	Unclear	Yes	No	Yes	Yes	Yes
Guragac et al. [29]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Unclear	Yes
Goh et al. [48]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Pawar et al. [59]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Unclear	Yes
Bueno-Gimeno et al. [77]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Unclear	Yes
Larsson et al. [2]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Nigam et al. [40]	Yes	Yes	Yes	Unclear	Unclear	Yes	No	Yes	Yes	Yes
Gama et al. [71]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Unclear	Yes
Turk et al. [30]	Yes	Yes	Yes	Unclear	Unclear	Yes	No	Yes	Yes	Yes
Yanni et al. [17]	Yes	Yes	Yes	Unclear	Unclear	Yes	No	Yes	Yes	Yes
Dave et al. [74]	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Lee et al. [46]	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Yau et al. [87]	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Lee et al. [88]	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Perez-Garcia et al. [31]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Dave et al. [68]	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Yes
Read et al. [41]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Sultan et al. [80]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Eslami et al. [32]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Passani et al. [54]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Rotruck et al. [18]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Read et al. [55]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tsai et al. [73]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Aykut et al. [82]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Unclear	Yes
Chen et al. [49]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Zhu et al. [33]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Bhoiwala et al. [72]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Kang et al. [60]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Grundy et al. [89]	Yes	No	Yes	No	No	Yes	No	Yes	Yes	Yes
Yabas Kiziloglu et al. [34]	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes
Yabas Kiziloglu et al. [90]	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Unclear	Yes

Table 1 (continued)

Authors and year	1. Were there clear criteria for inclusion in the case series?	2. Was the condition measured in a standard, reliable way for all participants included in the case series?	3. Were valid methods used for the identification of the condition for all participants included in the case series?	4. Did the case series have consecutive inclusion of participants?	5. Did the case series have complete inclusion of participants?	6. Was there clear reporting of the demographics of the participants in the study?	7. Was there clear reporting of clinical information of the participants?	8. Were the outcomes of cases clearly reported?	9. Was there clear reporting of the presenting site(s)/ clinic(s) demographic information?	10. Was statistical analysis appropriate?
Ayala and Ntoula [35]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Munoz-Gallego et al. [42]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Lee et al. [43]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes
Ali et al. [44]	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Yes

Table 3 comprises the values of the predefined peripapillary retinal nerve fibre layer (RNFL) thicknesses, as reported by the included studies. Other papers used additional optic disc parameters or employed custom-made scanning protocols (see Table 2 to identify such studies).

In Table 4 are included the values of the average and sectorial thicknesses of the macula. The ETDRS (Early Treatment Diabetic Retinopathy Study Research Group 1991) circular grid [10] scanning protocol was the most frequently used. Some studies also evaluated segmented retinal layers' thickness (results not included in Table 4).

Due to the high variability of both the OCT instruments and methodologies of the studies, a statistical analysis of the data was not feasible.

Discussion

Comments on our methodology

We included both hospital-based and population-based studies. Although population-based studies are preferable for the topic of our paper, the majority of studies are hospital based and valuable information would have been lost if we excluded this type of studies. Moreover, the inclusion and exclusion criteria for all the studies were thoroughly verified.

We chose arbitrarily the minimum number of participants included in the selected papers (i.e., 50 participants): although higher number of records is required for a database to be considered normative, there are several limitative factors for such a study to be conducted (e.g., collaboration of children, parent or tutor consent, experience of technicians, and others).

Risk of bias within the studies

Table 1 demonstrates that the highest risk of bias of the included studies is related to the consecutive inclusion of participants, and complete inclusion of participants, respectively.

Risk of bias across the studies

We observed a high variability of inclusion criteria and/or ophthalmological tests performed across the studies (i.e., selection bias)—e.g., visual acuity presented different ranges between studies, cycloplegia was performed only in some studies before the refraction measurement, and only a part of the studies also included the assessment of the intraocular pressure. Moreover, some investigators examined and/or included into analysis only one eye of each participant.

Table 2 Demographic and clinical characteristics of the studies included in the present review.

Authors and year	Study design	OCT equipment	No. of participants/ No. of eyes studied	Ethnicity/Race (country)	Mean age (years)	Sex (M/F)	Refraction error: mean SE ± 1 SD (dioptres)	Main OCT parameters studied
Time domain OCT								
Ahn et al. [20]	Hospital based	OCT III (Zeiss-Humphrey, San Leandro, CA, USA)	72/144	Korean 100% (Korea)	12.6 ± 2.13 (range 9–18)	33/39	−3.15 ± 2.2 (range −6 to +3)	Peripapillary RNFL thickness
Salchow et al. [45]	Hospital based	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	92/92	Hispanic 91% African American 8% Caucasian 1% (USA)	9.7 ± 2.7 (range 4–17)	34/58	−0.57 ± 2.43 (range −8.5 to +5)	Peripapillary RNFL thickness
Huynh et al. [12]	Population based[a]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	1369/1369	White 66.4% East Asian 15.6% Middle Eastern 3.7% Other 14.4% (Australia)	6.71 ± 0.4 (6 years old)	697/672	+1.29 ± 0.87 (range NA)	Peripapillary RNFL thickness[b]
Huynh et al. [11]	Population based[a]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	1543/1543	European white 65.4% East Asian 15.9% Middle Eastern 4.1% Other 14.6% (Australia)	Mean, SD NA (6 years old)	789/754	1.29 ± 0.89 (range NA)	Macular thickness
Luo et al. [79]	Population based	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	104/NA	Chinese 100% (Singapore)	11.5 ± 0.5 (range 11–12)	53/51	−1.38 ± 1.58 (range −4.5 to +1.10)	Macular thickness[b]
Huynh et al. [13]	Population based[a]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	1309/1309	European white 66.2% East Asian 15.1% Middle Eastern 4.1% Other 14.7% (Australia)	Mean, SD NA (6 years old)	666/643	1.28 ± 0.02	Optic disc parameters[b]
Samarawickrama et al. [78]	Population based[a]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	3529/NA	NA (Australia)	1395 children: 6.7 (SD and range NA) 2134 children: 12.7 (SD and range NA)	NA	NA	Optic disc parameters[b]
Jun and Lee [76]	Hospital based	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	51/102	NA (Korea)	10.1 ± 3.1 (range 4–15)	29/22	−2.5 ± 3.4 (range NA)	Optic disc parameters[b]
Huynh et al. [50]	Population based[a]	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	2353/NA	Caucasian 60.5–60.9% East Asian 14.1–14.5% Middle Eastern 7–7.1% Other 18% (Australia)	Mean, SD NA (range 11.1–14.4)	1223/1130	0.5 (SD NA) (range NA)	Macular thickness, Peripapillary RNFL thickness, Optic disc parameters[b]
El-Dairi et al. [14]	Hospital based	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	286/286	Black 40% White 54% Other 6% (USA)	8.59 ± 3.11 (range 3–17)	NA	Black: 0.27 (SD NA) White: 0.77 (SD NA) (range −6 to +6)	Macular thickness, Peripapillary RNFL thickness[b]
Eriksson et al. [36]	Population based[c]	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	56/55	Caucasian 100% (Sweden)	10.1 (SD NA) (range 5–16)	28/28	Mean SE NA (range −3 to +3)	Macular thickness, Macular volume
Samarawickrama et al. [85]	Population based[a]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	3382/NA	NA (Australia)	6.7; 12.7 (SD NA)	1765/1617	NA	Macular thickness, Peripapillary RNFL thickness, Optic disc parameters[b]
Leung et al. [21]	Hospital based	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	97/194	Chinese 100% (China)	9.75 (SD NA) (range 6–17)	46/51	OD: −0.81 ± 1.38 OS: −0.82 ± 1.33 (range −5 to +5)	Peripapillary RNFL thickness
Tariq et al. [15]	Population based[a]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	2092/NA	Caucasian 60.4% East Asian 14.3% South Asian 5.2% Middle Eastern 7.1% Other 13.0% (Australia)	12.7 ± 0.4 (range 11–14)	1086/1006	NA	Macular thickness, Peripapillary RNFL thickness[b]

Table 2 (continued)

Authors and year	Study design	OCT equipment	No. of participants/ No. of eyes studied	Ethnicity/Race (country)	Mean age (years)	Sex (M/F)	Refraction error: mean SE ± 1 SD (dioptres)	Main OCT parameters studied
Samarawickrama et al. [16]	Population based[a]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	6 years old: 1115/ 1115 12 year old: 1596/ 1596	6 years old: Caucasian 68.3% East Asian 13.9% South Asian 2.1% Middle Eastern 3.2% Other 12.5% 12 years old: Caucasian 65.8% East Asian 13.5% South Asian 4.8% Middle Eastern 4.5% Other 11.4% (Australia)	6.7 (SD and range NA) 12.7 (SD and range NA)	NA	6 years old: +1.3 (SD and range NA) 12 years old:+0.5 (SD and range NA)	Peripapillary RNFL thickness, optic disc parameters[b]
Larsson et al. [22]	Population based[c]	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	56/54	Caucasian 100% (Sweden)	10.1 ± 3 (range 5–16)	28/28	0.6 (SD NA) (range −3 to +3)	Peripapillary RNFL thickness
Zhang et al. [37]	Population based	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	720/720	Asian 100% (China)	8.63 ± 1.64 (range 6–13)	335/385	−0.36 ± 1.64 (range NA)	Macular thickness[b]
Tariq et al. [86]	Population based[a]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	2293/2293	NA (Australia)	12.7 ± 0.5 (12 years old)	NA	NA	Peripapillary RNFL thickness, macular thickness[b]
Qian et al. [69]	Hospital based	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	199/398	Asian 100% (China)	10.4 ± 2.7 (range 5–18)	101/98	Mean and SD NA (range −3 to +1)	Peripapillary RNFL thickness[b]
Tas et al. [58]	Hospital based	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	164/164	NA (Turkey)	9.0 ± 2.6 (range 4–15)	82/82	Low hyperopia group: 1.47 ± 1.0 Moderate hyperopia group: 4.4 ± 0.8 High hyperopia group: 7.3 ± 1.1	Peripapillary RNFL thickness
Pawar et al. [23]	Hospital based	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	120/120	Indian 100% (India)	10.8 ± 3.24 (range 5–17)	66/54	−0.93 ± 1.31 (range −4 to +1.5)	Peripapillary RNFL thickness[b]
Hong et al. [47]	Hospital based	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	198/198	NA (Korea)	8.61 ± 3.12 (range 2–18)	96/102	−0.7 ± 2.9 (range −9.75 to +6.75)	Peripapillary RNFL thickness[b]
Spectral domain OCT								
Allingham et al. [6]	Hospital based	Handheld OCT (Bioptigen, Inc, Research Triangle Park, NC, USA)	58/58	White 37.9% Black 25.9% Hispanic 36.2% (USA)	0–2 days	24/34	NA	Optic disc parameters[b]
Rothman et al. [7]	Hospital based	Handheld OCT (Bioptigen, Inc, Research Triangle Park, NC, USA)	50/50	Black 24% Hispanic 40% White 36% (USA)	39.2 ± 1.1 weeks	22/28	NA	Sectoral temporal peripapillary RNFL thickness[b]
Patel et al. [8]	Hospital based	Handheld ENVISU C (Bioptigen, Inc, Research Triangle Park, NC, USA)	218/218	NA (UK)	3.5 ± 3 (range 0–13)	96/122	Mean NA (range −3 to +3)	Optic disc parameters[b]
Lim et al. [9]	Hospital based	Handheld OCT (Bioptigen, Inc., Morrisville, NC, USA)	67/67	White 70.1% African American 13.4% Hispanic 3% Mixed race 12% Unknown 1.5% (USA)	2.5 ± 1.76 (range 0–6)	31/36	+1.49 ± 1.34 (range −2.25 to +4.25)	Macular ganglion cell complex thickness, Peripapillary RNFL thickness[b]
Elia et al. [24]	Population based	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	344/344	Caucasian 100% (Spain)	9.16 ± 1.7 (range 6–13)	NA	NA (range −2.50 to +6.25)	Peripapillary RNFL thickness, Optic nerve head parameters

Table 2 (continued)

Authors and year	Study design	OCT equipment	No. of participants/ No. of eyes studied	Ethnicity/Race (country)	Mean age (years)	Sex (M/F)	Refraction error: mean SE ± 1 SD (dioptres)	Main OCT parameters studied
Barrio-Barrio et al. [25]	Hospital based, multicentric	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	283/283	Caucasian 100% (Spain)	9.58 ± 3.12 (range 4–17)	117/166	+0.63 ± 1.65 (range −4.88 to +5.25)	Peripapillary RNFL thickness, Macular thickness
Rao et al. [26]	Hospital based	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	74/148	NA (India)	10 ± 3.4 (range 4–17)	37/37	−0.6 ± 1.2 (range NA)	Peripapillary RNFL thickness
Altemir et al. [70]	Population based	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	357/714	White 96% Other 4% (Spain)	9 ± 1.7 (range 6.11–13.58)	182/175	Mean and SD NA (range −3.00 to +4.50)	Peripapillary RNFL thickness, Optic nerve head parameters, Macular thickness
Katiyar et al. [51]	Hospital based	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	157/NA	North Indian 100% (India)	12.59 ± 3.5 (range 6–17)	112/45	NA (range −0.5 to +0.5)	Macular thickness
Oner et al. [81]	Hospital based	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	94/94	NA (Turkey)	Myopia: 10.9 ± 1.6 Emmetropia: 10.8 ± 3 Hyperopia: 10.3 ± 2.2 (range 5–15)	19/17 16/14 15/13	−2.56 ± 1.0 0.08 ± 0.1 +2.49 ± 0.7 (range −0.50 to +7.50)	Peripapillary RNFL thickness
Al-Haddad et al. [67]	Hospital based	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	108/216	White Middle Eastern 100% (Lebanon)	10.7 ± 3.1 (range 6–17)	43/65	RE: −0.02 ± 1.77 LE: + 0.01 ± 1.75 (range NA)	Peripapillary RNFL thickness, Macular thickness[b]
Galdos et al. [52]	Hospital based, multicentric	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	276/276	Caucasian 100% (Spain)	9.6 ± 3.13 (range 4–17)	114/162	+0.62 ± 1.68 (range −4 to +5)	Macular ganglion cell—inner plexiform layer thickness[b]
Al-Haddad et al. [27]	Hospital based	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	108/108	White Middle Eastern 100% (Lebanon)	10.7 ± 3.1 (range 6–17)	43/65	−0.02 ± 1.77 (range −4.25 to +5.00)	Peripapillary RNFL thickness, Macular thickness
Chen et al. [61]	Hospital based	Cirrus HD-OCT (Carl Zeiss Meditec, Dublin, CA, USA)	194/194	Chinese 100% (China)	10.15 ± 2.61 (range 6–17)	108/86	−2.25 ± 2.47 (range −11 to +0.5)	Macular thickness, Macular volume
Queiros et al. [28]	Hospital based	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	153/306	Caucasian 100% (Portugal)	9.54 ± 3.35 (range 4–17)	71/82	−0.39 ± 1.33 (range −5 to +5)	Peripapillary RNFL thickness, Macular thickness
Molnar et al. [38]	Population based[2]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	58/56	Caucasian 100% (Sweden)	10.6 ± 2.9 (range 6–15)	30/28	RE: 0.95 ± 0.63 (range −0.5 to +2.75) LE: 0.93 ± 0.71 (range 0.75 to +3)	Macular thickness
Totan et al. [53]	Hospital based	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	296/296	Turkish 100% (Turkey)	9.62 ± 4.1 (range 3–17)	125/171	−0.09 ± 1.49 (range −4 to +3)	Macular ganglion cell—inner plexiform layer thickness[b]
Sushil et al. [39]	Hospital based	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	59/117	Indian 100% (India)	Mean, SD NA (range 5–16)	36/23	Mean, SD NA (range NA)	Macular thickness
Guragac et al. [29]	Hospital based	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	318/318	NA (Turkey)	10.2 ± 4.1 (range 3–17)	138/180	−0.21 ± 1.47 (range −4.00 to +3.00)	Peripapillary RNFL thickness, Macular thickness
Goh et al. [48]	Hospital based	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	139/243	Chinese 77% Malay 6% Indian 10% Eurasian 1% Other 6% (Singapore)	9.47 ± 3.4 (range 3–18)	75/64	−3.20 ± 3.51 (range −12.8 to 7.75)	Peripapillary RNFL thickness, Macular ganglion cell—inner plexiform layer thickness[b]

Table 2 (continued)

Authors and year	Study design	OCT equipment	No. of participants/ No. of eyes studied	Ethnicity/Race (country)	Mean age (years)	Sex (M/F)	Refraction error: mean SE ± 1 SD (dioptres)	Main OCT parameters studied
Pawar et al. [59]	Hospital based	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	70/140	Indian 100% (India)	11.83 ± 3.3 (range 5–17)	43/27	RE: 0.61 ± 0.9 LE: 0.69 ± 0.9 (range NA)	Peripapillary RNFL thickness, Optic nerve head parameters
Bueno-Gimeno et al. [77]	Hospital based	Cirrus HD-OCT (Carl Zeiss Meditec, Dublin, CA, USA)	293/293	NA (Spain)	10.8 ± 3.1 (range 6–17)	145/148	0.14 ± 3.41 (range −8.75 to +8.25)	Peripapillary RNFL thickness, Optic nerve head parameters, Macular thickness
Larsson et al. [2]	Population based[c]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	57/110	Caucasian 100% (Sweden)	10.7 ± 2.8 (range 6–15)	29/28	RE: 0.95 ± 0.63 (range −0.5 to +2.75) LE: 0.93 ± 0.71 (range −0.75 to + 3)	Peripapillary RNFL thickness, Optic nerve head parameters
Nigam et al. [40]	Hospital based	Cirrus HD-OCT (Carl Zeiss Meditec, Dublin, CA, USA)	170/340	North Indian 100% (India)	10.4 ± 2.7 (range 5–17)	100/70	Mean, SD NA (range NA)	Macular thickness
Gama et al. [71]	Hospital based	Cirrus HD-OCT (Carl Zeiss Meditec, Dublin, CA, USA)	358/358	NA (Portugal)	6.41 ± 1.66 (range 4–11)	187/171	0.22 ± 0.5 (range NA)	Peripapillary RNFL thickness, Optic nerve head parameters, Ganglion cell—inner plexiform layer thickness[b]
Turk et al. [30]	Hospital based	Spectralis OCT (Heidelberg Engineering, Dossenheim, Germany)	107/107	NA (Turkey)	10.46 ± 2.94 (range 6–16)	53/54	−0.27 ± 0.99 (range −3.00 to +2.25)	Peripapillary RNFL thickness, Macular thickness
Yanni et al. [17]	Hospital based	Spectralis OCT (Heidelberg Engineering, Vista, CA, USA)	83/83	Non-Hispanic white 68.7% African American 6% Hispanic 8.5% Asian 7.2% Mixed race 7.2% Not reported 2.4% (USA)	Mean and SD NA (range 5–15)	45/38	NA	Peripapillary RNFL thickness, Macular thickness[b]
Dave et al. [74]	Hospital based	Spectralis OCT (Heidelberg Engineering, Carlsbad, CA, USA)	126/126	Indian 100% (India)	11.42 ± 3.59 (range 5–18)	60/66	−0.4 ± 1.4 (range NA)	Peripapillary RNFL thickness
Lee et al. [46]	Hospital based	Spectralis OCT (Heidelberg Engineering, Carlsbad, CA, USA)	201/201	Chinese 100% (China)	7.6 ± 3.3 (range 4–18)	103/98	Myopic group: −3.9 ± 2.2 Emmetropic group: +0.1 ± 0.5 Hyperopic group: +3.0 ± 1.6 (range NA)	Peripapillary RNFL thickness
Yau et al. [87]	Hospital based	Spectralis OCT (Heidelberg Engineering, Carlsbad, CA, USA)	168/168	Chinese 100% (China)	7.6 ± 3.3 (range 4–18)	83/85	Myopic group: −3.9 ± 2.2 Emmetropic group: +0.1 ± 0.5 Hyperopic group: +2.9 ± 1.5 (range NA)	Central macular thickness[b]
Lee et al. [88]	Hospital based	Spectralis OCT (Heidelberg Engineering, Carlsbad, CA, USA)	179/179	Chinese 100% (China)	7.9 ± 3.6 (range 4–18)	90/89	−0.1 ± 3.1 (range −10 to +8.9)	Peripapillary RNFL, Macular thickness
Perez-Garcia et al. [31]	Hospital based	Spectralis OCT (Heidelberg Engineering, Dossenheim, Germany)	162/NA	Caucasian 100% (Spain)	8.1 ± 3.03 (range 3–14)	69/93	0.03 ± 0.19 (range NA)	Peripapillary RNFL thickness, Macular thickness
Dave et al. [68]	Hospital based	Spectralis OCT (Heidelberg Engineering, Carlsbad, CA, USA)	126/252	Indian 100% (India)	11.2 ± 3.2 (range 5–15)	60/66	−0.4 ± 1.4 (range NA)	Peripapillary RNFL thickness, Macular thickness[b]

Table 2 (continued)

Authors and year	Study design	OCT equipment	No. of participants/ No. of eyes studied	Ethnicity/Race (country)	Mean age (years)	Sex (M/F)	Refraction error: mean SE ± 1 SD (dioptres)	Main OCT parameters studied
Read et al. [41]	Hospital based	Spectralis OCT (Heidelberg Engineering, Heidelberg, Germany)	101/101	NA (Australia)	13.1 ± 1.4 (range 10–15)	48/53	−0.76 ± 1.67 (range −8.00 to +1.00)	Macular thickness[b]
Sultan et al. [80]	Hospital based	Spectralis OCT (Heidelberg Engineering, Heidelberg, Germany)	50/50	NA (Pakistan)	Mean and SD NA (range 5–8)	25/25	High myopic group: −9.39 ± 2.79 Control group: +0.81 ± 1.00 (range NA)	Macular thickness[b]
Eslami et al. [32]	Hospital based	Spectralis OCT (Heidelberg Engineering, Vista, CA, USA)	120/120	Iranian 100% (Iran)	12.44 ± 2.52 (range 8–17)	69/51	0.39 ± 1.38 (range −3.00 to +4.50)	Peripapillary RNFL thickness
Passani et al. [54]	Hospital based	Spectralis OCT (Heidelberg Engineering, Dossenheim, Germany)	94/94	Caucasian 100% (Italy)	10.5 (SD NA) (range 5–18)	49/45	0.33 ± 1.41 (range −4.00 to +4.00)	Macular thickness
Rotruck et al. [18]	Hospital based	Portable HRA + OCT Spectralis (investigational device)	57/57	White 54% Black 12% Asian 3.5% Mixed race 14% Unknown/not reported 16.5% (USA)	2.28 ± 1.50 (range 0–5)	28/29	NA	Peripapillary RNFL thickness, Macular thickness
Read et al. [55]	Population based	Copernicus SOCT-HR (Optopol Technology SA, Zawiercie, Poland)	196/NA	White 90% East Asian 4% Middle Eastern 3% South American 1% Melanesian 1% Indian 1% (Australia)	8.2 ± 1.9 (range 4–12)	96/100	+0.06 ± 0.21 (range −0.5 to +1.25)	Macular thickness[b] (total and retinal layers)
Tsai et al. [73]	Population based	RTVue-100 OCT (Optovue, Fremont, CA, USA)	470/470	Chinese 100% (Taiwan)	9.2 (SD NA) (range 6.5–12.5)	236/234	−0.7 (SD and range NA)	Peripapillary RNFL thickness
Aykut et al. [82]	Hospital based	RTVue OCT (Optovue, Fremont, CA, USA)	120/120	NA (Turkey)	Myopia: 10.4 ± 2.1 Emmetropia: 10.2 ± 1.8 Hyperopia: 9.4 ± 2.4 (range 5–15)	58/62	Myopia: −2.8 ± 1.6 Emmetropia: 0.24 ± 0.0 Hyperopia: +3.6 ± 2.4	Peripapillary RNFL thickness
Chen et al. [49]	Population based	iVue 100 (Optovue, Fremont, CA, USA)	2324/4648	Chinese 100% (China)	12.82 ± 3.11 (range 6–17)	1197/1127	NA	Peripapillary RNFL thickness
Zhu et al. [33]	Population based	iVue 100 (Optovue, Fremont, CA, USA)	1955/1955	Chinese 100% (China)	12.34 ± 0.58 (range 10–16)	976/979	−1.38 ± 1.95 (range NA)	Peripapillary RNFL thickness
Bhoiwala et al. [72]	Population based	RTVue Avanti (Optovue, Fremont, CA, USA)	77/77	NA (USA)	5.08 (SD and range NA)	41/36	RE: + 0.89, SD NA (range −1.25 to +3.00) LE: + 0.81, SD NA (range −0.75 to +2.75)	Peripapillary RNFL thickness, Optic nerve head parameters, Thickness map of ganglion cell complex[b]
Kang et al. [60]	Population based	iVue 100 (Optovue, Fremont, CA, USA)	1811/1811	NA (China)	7.1 ± 0.4 (range 5–9)	1021/790	0.92 ± 0.89 (range −3.63 to +5.00)	Peripapillary RNFL thickness., Optic nerve head parameters[b]
Grundy et al. [89]	Population based	iScan OCT (Optovue, Fremont, CA, USA)	258/NA	Kenya 49.6% Bhutan 50.4%	6.4 ± 1.5 (range 3–11)	119/139	NA	Peripapillary RNFL thickness, Optic nerve head parameters, Thickness map of ganglion cell complex[b]

Table 2 (continued)

Authors and year	Study design	OCT equipment	No. of participants/ No. of eyes studied	Ethnicity/Race (country)	Mean age (years)	Sex (M/F)	Refraction error: mean SE ± 1 SD (dioptres)	Main OCT parameters studied
Yabas Kiziloglu et al. [34]	Hospital based	iVue 100 (Optovue, Fremont, CA, USA)	202/202	NA (Turkey)	10.4 ± 3.4 (range 5–17)	99/103	5–8 years: 0.72 ± 1.51 (range −3.3 to +4.5) 9–12 years: −0.01 ± 1.51 (range −4.3 to +5.9) 13–17 years: −0.67 ± 2.05 (range 5.8 to +3.9)	Peripapillary RNFL thickness, Macular thickness
Yabas Kiziloglu et al. [90]	Hospital based	iVUe 100 (Optovue, Fremont, CA, USA)	128/128	NA (Turkey)	10.87 ± 3.50 (range 5–17)	68/60	−0.10 ± 2.03 (range −6.00 to +5.88)	Optic nerve head parameters[b]
Ayala and Ntoula [35]	Hospital based	Topcon 3D OCT 2000 (Topcon Corporation, Tokyo, Japan)	80/138	Swedish 100% (Sweden)	9.1 (SD NA) (range 3.8 to 16.7)	35/45	+1.7 (SD NA) (range −5.25 to +7.5)	Peripapillary RNFL thickness
Munoz-Gallego et al. [42]	Hospital based	Topcon 3D OCT 2000 (Topcon Corporation, Tokyo, Japan)	126/250	European origin 82.5% Other 17.5% (Spain)	10.3 ± 3.4 (range 5.0 to 17.4)	61/65	+0.88 ± 1.49 (range −3.38 to +4.63)	Macular thickness[b]
Lee et al. [43]	Hospital based	SS-OCT DRI OCT Triton (Topcon Corporation, Tokyo, Japan)	127/254	NA (Korea)	9.52 ± 3.79 (range 3–17)	62/65	−1.19 ± 3.08 (range −12.00 to +7.25)	Peripapillary RNFL thickness, Macular thickness[b]
Ali et al. [44]	Hospital based	Triton Plus OCT 3D DRI OCT Triton (Topcon Corporation, Tokyo, Japan)	50/100	NA (Egypt)	10.96 ± 2.75 (range 6–17)	25/25	0.78 ± 1.65 (range −4.50 to +5.00)	Peripapillary RNFL thickness, Macular thickness

LE left eye, *NA* information not available, *RE* right eye, *SD* standard deviation, *SE* spherical equivalent.

[a]Sydney Childhood Eye Study.

[b]Additional and/or nonstandard OCT parameters were assessed.

[c]Sweden Study.

Table 3 Results of OCT measurement of peripapillary RNFL thickness.

Authors and year	OCT equipment	Mean age (years)	Classification	Mean RNFL (Mean ± SD or Mean and 5th−95th percentile, μm)	Superior quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, μm)	Temporal quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, μm)	Inferior quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, μm)	Nasal quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, μm)
Time domain OCT								
Ahn et al. [20]	OCT III (Zeiss-Humphrey, San Leandro, CA, USA)	12.6 ± 2.13 (range 9–18)	RE	106.79 ± 12.98	132.73 ± 23.90	85 ± 14.93	133.34 ± 25.32	75.62 ± 13.62
			LE	104.28 ± 7.68	132.75 ± 16.42	90.47 ± 20.45	130.92 ± 15.04	63.65 ± 14.10
Salchow et al. [45]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	9.7 ± 2.7 (range 4–17)	–	108.0 ± 11.4	135.4 ± 19.3	72.5 ± 13.4	136.9 ± 16.9	83.0 ± 18.0
Huynh et al. [12]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	6.71 ± 0.4 (6 years old)	–	103.7 ± 11.4	129.5 ± 20.6	75.7 ± 14.7	127.8 ± 20.5	81.7 ± 19.6
Huynh et al. [50]	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	Mean, SD NA (range 11.1–14.4)	-	103.6 ± 10.6	129.7 ± 17.5	74.6 ± 12.8	128.3 ± 18.6	82.0 ± 16.7
El-Dairi et al. [14]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	8.59 ± 3.11 (range 3–17)	3–6 years	109 (94–126)	143 (112–178)	77 (58–109)	131 (103–163)	84 (53–124)
			7–10 years	107 (90–123)	138 (113–174)	79 (55–101)	128 (99–158)	81 (59–115)
			11–17 years	109 (93–124)	144 (111–173)	80 (60–106)	129 (102–160)	84 (57–112)
Leung et al. [21]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	9.75 (SD NA) (range 6–17)	RE	113.5 ± 9.8	146.3 ± 16.3	87.3 ± 15.4	142.4 ± 18.4	78.3 ± 16.1
			LE	113.1 ± 10.8	148.6 ± 19.5	86.6 ± 16.6	143.2 ± 8.7	74.2 ± 14.8
Tariq et al. [15]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	12.7 ± 0.4 (range 11–14)	Caucasian	103.5 (SD NA)	128.3 (SD NA)	73.04 (SD NA)	128.5 (SD NA)	84.41 (SD NA)
			East Asian	105.7 (SD NA)	135.7 (SD NA)	82.53 (SD NA)	130.6 (SD NA)	73.85 (SD NA)
			South Asian	99.8 (SD NA)	127.1 (SD NA)	71.91 (SD NA)	123.5 (SD NA)	76.70 (SD NA)
			Middle Eastern	101.2 (SD NA)	125.2 (SD NA)	74.44 (SD NA)	125.0 (SD NA)	80.17 (SD NA)
Samarawickrama et al. [16]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	6.7 (SD and range NA)	6 years old:					
			European Caucasian	101.95 (SD NA)	124.71 (SD NA)	78.98 (SD NA)	124.89 (SD NA)	79.43 (SD NA)
			East Asian	105.45 (SD NA)	132.34 (SD NA)	85.26 (SD NA)	130.63 (SD NA)	74.11 (SD NA)
		12.7 (SD and range NA)	12 years old:					
			European Caucasian	104.57 (SD NA)	131.09 (SD NA)	71.13 (SD NA)	129.84 (SD NA)	86.40 (SD NA)
			East Asian	107.92 (SD NA)	139.86 (SD NA)	79.70 (SD NA)	134.23 (SD NA)	77.66 (SD NA)
Larsson et al. [22]	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	10.1 ± 3 (range 5–16)	–	98.4 ± 7.88	123 (SD and percentiles NA)	70 (SD and percentiles NA)	125 (SD and percentiles NA)	77 (SD and percentiles NA)
Tariq et al. [86]	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	12.7 ± 0.5 (12 years old)	Birth weight (g):					
			<2500	98.2 (SD NA)	126.1 (SD NA)	73.8 (SD NA)	119.8 (SD NA)	73.0 (SD NA)
			2500–4000	103.5 (SD NA)	130.4 (SD NA)	75.6 (SD NA)	128.7 (SD NA)	79.3 (SD NA)
			>4000	105.9 (SD NA)	133.2 (SD NA)	76.8 (SD NA)	130.2 (SD NA)	83.2 (SD NA)
			Gestational duration (weeks)					
			≤32	98.9 (SD NA)	126.5 (SD NA)	74.7 (SD NA)	121.6 (SD NA)	73.1 (SD NA)
			33–36	102.5 (SD NA)	129.5 (SD NA)	72.7 (SD NA)	127.0 (SD NA)	80.8 (SD NA)
			≥37	103.4 (SD NA)	130.0 (SD NA)	75.5 (SD NA)	128.2 (SD NA)	79.7 (SD NA)

Table 3 (continued)

Authors and year	OCT equipment	Mean age (years)	Classification	Mean RNFL (Mean ± SD or Mean and 5th−95th percentile, µm)	Superior quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, µm)	Temporal quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, µm)	Inferior quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, µm)	Nasal quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, µm)
Qian et al. [69]	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	10.4 ± 2.7 (range 5–18)	–	112.36 ± 9.21	148.73 ± 17.06	83.82 ± 13.53	142.08 ± 16.03	74.84 ± 15.03
Tas et al. [58]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	9.0 ± 2.6 (range 4–15)	Low hyperopia	104.5 ± 11.0	126.7 ± 17.5	74.3 ± 14.4	138.1 ± 17.5	78.9 ± 19.1
			Moderate hyperopia	106.8 ± 11.4	125.4 ± 15.7	74.8 ± 15.5	140.8 ± 19.3	86.1 ± 22.2
			High hyperopia	111.1 ± 12.3	130.7 ± 19.4	71.8 ± 11.8	151.6 ± 21.6	91.3 ± 17.2
Pawar et al. [23]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	10.8 ± 3.24 (range 5–17)	–	106.11 ± 9.51	133.44 ± 15.5	70.72 ± 14.81	134.1 ± 16.16	84.27 ± 16.43
Hong et al. [47]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	8.61 ± 3.12 (range 2–18)	Observed thickness	107.71 ± 11.83	NA	NA	NA	NA
			Ocular magnification-corrected thickness	103.3 ± 12.53	NA	NA	NA	NA
Spectral domain OCT								
Elia et al. [24]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	9.16 ± 1.7 (range 6–13)	<7 years	96.29 ± 9.86	120.12 ± 19.41	68.85 ± 13.85	129.02 ± 17.91	67.46 ± 15.37
			7–8 years	97.98 ± 13.09	124.26 ± 26.39	68.98 ± 11.47	127.91 ± 18.98	71.06 ± 14.31
			8–9 years	99.13 ± 11.05	124.73 ± 17.48	70.42 ± 11.42	129.82 ± 19.03	72.60 ± 12.54
			9–10 years	97.98 ± 12.35	121.11 ± 22.45	67.45 ± 10.53	131.89 ± 21.56	71.35 ± 14.16
			10–11 years	100.06 ± 9.00	124.83 ± 15.36	71.02 ± 11.52	130.89 ± 18.34	73.66 ± 11.05
			>11 years	98.66 ± 9.05	125.92 ± 16.12	69.00 ± 10.76	129.57 ± 15.01	70.25 ± 13.11
Barrio- Barrio et al. [25]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	9.58 ± 3.12 (range 4–17)	4–7 years	99.0 (83.8–115.3)	126.9 (96.1–154.2)	69.2 (52.4–85.6)	131.2 (103.7–164.9)	69.8 (51.1–98.0)
			8–12 years	97.2 (81.6–113.2)	125.0 (99.3–152.3)	66.5 (52.6–81.5)	128.2 (106.0–153.9)	69.1 (54.2–88.0)
			13–17 years	95.7 (82.5–113.5)	120.6 (94.3–153.3)	67.1 (49.8–84.8)	122.8 (98.5–146.5)	71.4 (47.2–99.4)
Rao et al. [26]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	10 ± 3.4 (range 4–17)	<7 years	92 ± 8.6	125 ± 17.3	60 ± 8.3	124 ± 12.6	77 ± 8.3
			7–13 years	94 ± 11.4	124 ± 15.9	62 ± 8.5	117 ± 14.2	69 ± 15.3
			14–17 years	92 ± 11.7	126 ± 16.1	61 ± 11.9	112 ± 15.4	67 ± 12.4
Altemir et al. [70]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	9 ± 1.7 (range 6.11–13.58)	RE	98.5 (SD NA)	123.61 (SD NA)	69.32 (SD NA)	130.42 (SD NA)	71.25 (SD NA)
			LE	97.76 (SD NA)	125.88 (SD NA)	65.73 (SD NA)	131.24 (SD NA)	68.66 (SD NA)
Oner et al. [81]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	10.9 ± 1.6	Myopia	89.0 ± 6.6	112.8 ± 10.6	60.1 ± 9.1	116.7 ± 13.0	67.1 ± 11.2
		10.8 ± 3	Emmetropia	93.3 ± 7.9	119.9 ± 10.4	63.1 ± 7.0	115.9 ± 16.5	73.7 ± 14.5
		10.3 ± 2.2 (range 5–15)	Hyperopia	98.6 ± 9.1	122.8 ± 12.4	67.5 ± 9.0	127.3 ± 19.2	78.3 ± 16.2
Al-Haddad et al. [67]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	10.7 ± 3.1 (range 6–17)	6–9 years	98 (84–111)	123 (99–151)	69 (56–87)	129 (91–163)	70 (49–89)
			9–12 years	93(80–106)	118 (96–142)	64 (51–83)	122 (101–150)	71 (51–83)
			12–15 years	98 (82–111)	122 (102–145)	68 (57–83)	127 (95–160)	71 (49–95)
			15–17 years	92 (80–101)	117 (93–131)	63 (53–75)	118 (97–131)	69 (43–113)
Queiros et al. [28]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	9.54 ± 3.35 (range 4–17)	–	97.9 ± 9.32	126.91 ± 16.51	65.17 ± 8.91	129.58 ± 15.05	69.72 ± 10.47

Table 3 (continued)

Authors and year	OCT equipment	Mean age (years)	Classification	Mean RNFL (Mean ± SD or Mean and 5th−95th percentile, μm)	Superior quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, μm)	Temporal quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, μm)	Inferior quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, μm)	Nasal quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, μm)
Guragac et al. [29]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	10.2 ± 4.1 (range 3–17)	3–6 years	99.33 (85.5–118)	126.22 (98–154.5)	69.33 (52–91)	129.66 (99–161)	72.4 (54–93)
			7–11 years	95.45 (80–114)	121.58 (95.7–148)	67.59 (54–84)	123.95 (96–150)	68.24 (53–90)
			12–17 years	95.78 (78–112)	120.66 (93.4–149)	66.6 (52–85.6)	125.31 (97–158)	70.30 (54–91)
Goh et al. [48]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	9.47 ± 3.4 (range 3–18)	–	99 ± 11.45	123.2 ± 25.81	75.8 ± 1.37	124.24 ± 22.23	72.86 ± 1.14
Pawar et al. [59]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	11.83 ± 3.3 (range 5–17)	RE	93.6 ± 9.5	114.57 ± 16.5	62.59 ± 8.4	122.36 ± 16.8	72.71 ± 15.3
			LE	94.7 ± 8	121.31 ± 13.9	59.54 ± 10.1	122.69 ± 17.3	73.8 ± 18.2
Bueno- Gimeno et al. [77]	Cirrus HD-OCT (Carl Zeiss Meditec, Dublin, CA, USA)	10.8 ± 3.1 (range 6–17)	Myopia	95.2 ± 10.04	121.89 ± 25	72.47 ± 15.98	116.7 ± 17.81	65.16 ± 12.29
			Emmetropia	100.39 ± 11.31	123.53 ± 23.81	74.51 ± 17.78	130.11 ± 21.33	72.12 ± 16.77
			Hyperopia	103.2 ± 10.91	125.6 ± 18.9	71.15 ± 15.07	130.82 ± 26.64	73.53 ± 14.63
			AL < 22 mm	104.78 ± 10.59	126.31 ± 17.56	69.62 ± 15.35	137.4 ± 22.54	76.26 ± 14.61
			AL 22–25 mm	98.75 ± 10.85	124.56 ± 24.16	73.45 ± 16.16	124.05 ± 21.67	68.95 ± 14.76
			AL > 25 mm	93.17 ± 10.19	113.72 ± 21.88	74.83 ± 18.6	112.61 ± 21.55	65.22 ± 14.49
Larsson et al. [2]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	10.7 ± 2.8 (range 6–15)	–	99.2 ± 8.8	123.2 ± 14.8	67.8 ± 8.2	130.8 ± 15.1	74.4 ± 11.5
Gama et al. [71]	Cirrus HD-OCT (Carl Zeiss Meditec, Dublin, CA, USA)	6.41 ± 1.66 (range 4–11)	–	100.19 ± 10.1	127.08 ± 18.26	67.72 ± 9.85	131.58 ± 18.31	75.18 ± 13.84
Turk et al. [30]	Spectralis OCT (Heidelberg Engineering, Dossenheim, Germany)	10.46 ± 2.94 (range 6–16)			Temporal superior:		Temporal Inferior:	
			Male	104.75 ± 9.13	136.15 ± 16.5	72.85 ± 7.8	141.23 ± 16.74	71.15 ± 9.8
			Female	108.12 ± 9.47	141.74 ± 18.3	75.74 ± 10.71	147.98 ± 17.05	71.93 ± 10.32
					Nasal superior:		Nasal Inferior:	
			Male		100.68 ± 15.26		106.43 ± 21.89	
			Female		104.96 ± 16.48		106.37 ± 16.18	
Yanni et al. [17]	Spectralis OCT (Heidelberg Engineering, Vista, CA, USA)	Mean and SD NA (range 5–15)			Temporal superior:		Temporal Inferior:	
			Male	107.7 ± 1.6	146.5 ± 2.9	76.1 ± 2.8	145.2 ± 2.9	84.9 ± 2.9
			Female	107.4 ± 1.7	143.5 ± 3.2	77.0 ± 2.6	149.0 ± 3.2	84.1 ± 2.3
					Nasal superior:		Nasal Inferior:	
			Male		117.7 ± 3.4		124.7 ± 4.4	
			Female		114.5 ± 4.5		126.2 ± 4.0	
Dave et al. [74]	Spectralis OCT (Heidelberg Engineering, Carlsbad, CA, USA)	11.42 ± 3.59 (range 5–18)	–	100.3 ± 8.3	125.2 ± 18.3	74.1 ± 10.9	127.2 ± 11.1	74.8 ± 13.8
Lee et al. [88]	Spectralis OCT (Heidelberg Engineering, Carlsbad, CA, USA)	7.9 ± 3.6 (range 4–18)	–	102.5 ± 14.3	126.2 ± 23.1	87.9 ± 19.9	131.0 ± 24.9	64.5 ± 19.8

Table 3 (continued)

Authors and year	OCT equipment	Mean age (years)	Classification	Mean RNFL (Mean ± SD or Mean and 5th−95th percentile, µm)	Superior quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, µm)	Temporal quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, µm)	Inferior quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, µm)	Nasal quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, µm)
Perez-Garcia et al. [31]	Spectralis OCT (Heidelberg Engineering, Dossenheim, Germany)	8.1 ± 3.03 (range 3–14)	–	100.45 ± 1.98	123.91 ± 2.72	73.25 ± 1.69	130.26 ± 2.58	71.55 ± 1.9
Eslami et al. [32]	Spectralis OCT (Heidelberg Engineering, Vista, CA, USA)	12.44 ± 2.52 (range 8–17)	–	101.01 ± 7.74	129.25 ± 14.52	69.58 ± 9.94	128.16 ± 13.46	76.76 ± 10.58
Rotruck et al. [18]	Portable HRA + OCT Spectralis (investigational device)	2.28 ± 1.50 (range 0–5)	–	107.6 ± 10.3	132.6 ± 18.5	77.2 ± 12.4	141.3 ± 17.6	78.6 ± 18.3
Tsai et al. [73]	RTVue-100 OCT	9.2 (SD NA)	Non-myopia	111.2 (110–112.4)	136 (134–138.1)	87.8 (86.2–89.3)	147 (144.7–149.3)	74 (72.7–75.3)
	(Optovue, Fremont, CA, USA)	(range 6.5 to 12.5)	Myopia	107 (105.6–108.3)	131 (128.4–133.6)	94 (91.8–96.1)	135.7 (133.2–138.2)	67.2 (65.7–68.6)
Aykut et al. [82]	RTVue OCT (Optovue, Fremont, CA, USA)	Myopia: 10.4 ± 2.1 Emmetropia: 10.2 ± 1.8 Hyperopia: 9.4 ± 2.4 (range 5–15)	Myopia	113.2 ± 9.4	Superotemporal:	Lower temporal:	Inferotemporal:	Lower Nasal:
			Emmetropia	117.3 ± 13.7	156.4 ± 16.8	79.3 ± 17.1	143.0 ± 17.6	79.8 ± 13.9
			Hyperopia	124.7 ± 11.3	158.3 ± 21.3	70.2 ± 17.3	147.6 ± 28.2	84.5 ± 14.8
					170.4 ± 22.6	82.6 ± 21.0	148.3 ± 24.3	93.7 ± 19.8
					Superonasal:	Upper temporal:	Inferonasal:	Upper Nasal:
					125.7 ± 17.0	92.9 ± 17.7	132.7 ± 22.9	93.8 ± 17.3
					134.1 ± 21.6	84.7 ± 19.1	143.5 ± 30.7	99.2 ± 21.9
					148.7 ± 26.2	101.3 ± 21.0	153.6 ± 30.4	98.6 ± 19.0
Chen et al. [49]	iVue 100 (Optovue, Fremont, CA, USA)	12.82 ± 3.11 (range 6–17)	RE	108.28 ± 13.97	133.22 ± 19.48	93.58 ± 29.15	129.23 ± 20.30	77.10 ± 14.89
			LE	107.01 ± 11.41	132.31 ± 19.12	86.76 ± 14.63	129.10 ± 20.07	79.89 ± 24.43
			Male	104.67 ± 11.04	132.98 ± 18.95	91.69 ± 28.78	127.30 ± 19.89	77.55 ± 15.67
			Female	109.24 ± 14.13	133.47 ± 20.03	95.59 ± 29.42	131.28 ± 20.54	76.63 ± 14.01
Zhu et al. [33]	iVue 100 (Optovue, Fremont, CA, USA)	12.34 ± 0.58 (range 10–16)	–	103.08 ± 9.01	126.19 ± 15.24	82.98 ± 10.57	129.34 ± 14.90	73.82 ± 13.89
Bhoiwala et al. [72]	RTVue Avanti (Optovue, Fremont, CA, USA)	5.08 (SD and range NA)	–	103.92 ± 10.59	123.79 ± 15.27	77.61 ± 10.03	132.16 ± 15.44	82.15 ± 16.16
Kang et al. [60]	iVue 100 (Optovue, Fremont, CA, USA)	7.1 ± 0.4 (range 5–9)	–	102.01 ± 0.19	125.07 ± 0.32	80.21 ± 0.22	126.80 ± 0.34	75.94 ± 0.32
			Male	101.98 ± 0.25	125.45 ± 0.44	80.07 ± 0.30	126.34 ± 0.45	76.04 ± 0.44
			Female	102.08 ± 0.28	124.65 ± 0.51	80.39 ± 0.32	127.43 ± 0.52	75.82 ± 0.48
			Myopia	99.17 ± 7.69	121.87 ± 13.98	79.57 ± 9.29	122.06 ± 12.95	73.17 ± 14.45
			Emmetropia	100.81 ± 7.18	123.51 ± 12.16	79.63 ± 8.46	125.15 ± 14.01	74.92 ± 12.33
			Hyperopia	102.45 ± 8.13	125.61 ± 14.22	80.36 ± 9.74	127.48 ± 15.09	76.35 ± 13.88
Grundy et al. [89]	iScan OCT (Optovue, Fremont, CA, USA)	6.4 ± 1.5 (range 3–11)	Bhutan					
			RE	108.6 ± 11.5	110.6 ± 14.5	79.8 ± 12.9	106.9 ± 11.2	83.8 ± 15.2
			LE	108.8 ± 9.2	111.7 ± 12.1	75.6 ± 10.9	106.1 ± 9.0	83.0 ± 15.3
			Kenya					
			RE	108.1 ± 9.2	109.3 ± 10.4	79.8 ± 13.0	106.9 ± 9.5	87.2 ± 16.6
			LE	108.5 ± 10.4	111.4 ± 11.4	77.2 ± 9.9	105.6 ± 10.8	85.4 ± 13.2

Table 3 (continued)

Authors and year	OCT equipment	Mean age (years)	Classification	Mean RNFL (Mean ± SD or Mean and 5th−95th percentile, µm)	Superior quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, µm)	Temporal quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, µm)	Inferior quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, µm)	Nasal quadrant RNFL (Mean ± SD or Mean and 5th–95th percentile, µm)
Yabas Kiziloglu et al. [34]	iVue 100 (Optovue, Fremont, CA, USA)	10.4 ± 3.4 (range 5–17)	–	103.9 ± 8.2	126.8 ± 12.2	76.2 ± 8.2	130.6 ± 14.2	82.2 ± 10.9
Ayala and Ntoula [35]	Topcon 3D OCT 2000 (Topcon Corporation, Tokyo, Japan)	9.1 (SD NA) (range 3.8–16.7)	–	105 ± 10.3	112.7 ± 16.5	NA	132.6 ± 18.3	NA
Ali et al. [44]	Triton Plus OCT (3D DRI OCT Triton, Topcon Corporation, Tokyo, Japan)	10.96 ± 2.75 (range 6–17)	–	111.26 ± 20.46	137.38 ± 24.62	76.29 ± 17.68	140.71 ± 28.48	90.39 ± 21.90

AL axial length, *LE* left eye, *NA* information not available, *RE* right eye, *SD* standard deviation.

Influence of ethnicity on OCT parameters

The influence of race or ethnicity on the OCT parameters was reported by the following authors:

(1) Huynh et al. [11]: Central and inner macular thickness is higher in white children compared with East Asians, and the thickness of the outer temporal macular region is higher in Middle Eastern children compared with whites.
(2) Huynh et al. [12]: Both the average and sectorial RNFL thicknesses are higher in white participants compared with East Asians.
(3) Huynh et al. [13]: East Asians had larger optic discs, but smaller neural rim areas than European white children.
(4) El-Dairi et al. [14]: The inner macular thickness, foveal thickness and total macular volume were greater in white children compared with black children, whereas the thicknesses of average RNFL and superior quadrant of RNFL were higher in black than in white children.
(5) Tariq et al. [15]: East Asians demonstrated the strongest relationship between axial length and retinal OCT parameters; Caucasians had smaller correlations with axial length for retinal OCT parameters, except for foveal minimum and central macular thickness; Middle Eastern children presented strong negative correlation of axial length with outer macular thickness and macular volume; South Asians had a positive correlation between the thickness of the temporal sector of RNFL and axial length.
(6) Samarawickrama et al. [16]: The RNFL thickness and optic cup size were higher in East Asian children compared with European Caucasians.
(7) Allingham et al. [6]: Black infants had larger vertical cup diameter than whites, and Hispanic infants had larger vertical disc diameter than whites.
(8) Rothman et al. [7]: Superior-temporal sector of RNFL presented greater thickness in blacks and Hispanics than in whites.
(9) Yanni et al. [17]: No significant effect of race or ethnicity on central macular or average RNFL thicknesses was found.
(10) Rotruck et al. [18]: There was no relationship between RNFL thickness and race.

The other papers included in this analysis did not evaluate the possible association between ethnicity or race and the OCT parameters.

Studies conducted on adult participants reported ethnic differences in the structures of the eye that are commonly imaged [19]. These results are difficult to compare with the

Table 4 Results of OCT measurement of macular thickness.

Authors and year	OCT equipment	Classification	Mean macular thickness (Mean ± SD or Mean and 5th–95th percentile, µm)	A1 (Mean ± SD or Mean and 5th–95th percentile, µm)	A2 (Mean ± SD or Mean and 5th–95th percentile, µm)	A3 (Mean ± SD or Mean and 5th–95th percentile, µm)	A4 (Mean ± SD or Mean and 5th–95th percentile, µm)	A5 (Mean ± SD or Mean and 5th–95th percentile, µm)	A6 (Mean ± SD or Mean and 5th–95th percentile, µm)	A7 (Mean ± SD or Mean and 5th–95th percentile, µm)	A8 (Mean ± SD or Mean and 5th–95th percentile, µm)	A9 (Mean ± SD or Mean and 5th–95th percentile, µm)
Time domain OCT												
Huynh et al. [11]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	–	NA	193.6 ± 17.9	269.7 ± 15.1	256.2 ± 16.5	266.7 ± 15.1	264.8 ± 18.7	239.5 ± 13.9	223.1 ± 15.2	230.9 ± 14.1	254.1 ± 17.9
Luo et al. [79]	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	No myopia	168.1 ± 34.3	NA	275.3 ± 13.7	259.4 ± 11.9	265.1 ± 13.7	270.5 ± 14.8	239.0 ± 11.8	220.7 ± 12.3	238.7 ± 13.4	261.2 ± 15.4
		Low myopia	170.9 ± 35.9		270.3 ± 14.8	254.5 ± 14.8	260.8 ± 13.3	265.8 ± 16.8	233.1 ± 11.8	212.5 ± 12.7	225.8 ± 11.0	251.8 ± 12.9
		Moderate myopia	178.8 ± 39.2		266.0 ± 12.8	250.0 ± 11.4	257.7 ± 11.3	259.0 ± 15.3	228.7 ± 12.8	207.6 ± 12.7	223.2 ± 13.4	247.9 ± 13.6
		AL < 23.23 mm	173.5 ± 40.2	NA	265.8 ± 12.3	249.6 ± 11.9	257.3 ± 12.5	260.4 ± 15.8	228.0 ± 12.3	206.9 ± 12.0	222.4 ± 13.2	246.8 ± 14.5
		AL 23.24–24.3	170.2 ± 33.3		270.1 ± 13.0	255.2 ± 13.0	260.9 ± 11.4	264.7 ± 13.9	232.8 ± 9.5	213.9 ± 10.8	228.6 ± 9.3	252.9 ± 9.7
		AL > 24.31 mm	170.6 ± 34.8		278.2 ± 15.1	261.5 ± 13.0	267.2 ± 14.2	273.6 ± 16.3	242.6 ± 13.3	223.1 ± 12.9	239.5 ± 13.8	264.1 ± 14.9
Huynh et al. [50]	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	–	NA	197.4 ± 18.7	275.8 ± 15.2	263 ± 15.5	274.1 ± 15.1	275 ± 17.1	242.3 ± 13.9	225.9 ± 14.8	231.5 ± 14.4	258.4 ± 16.4
El-Dairi et al. [14]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	3–6 years	NA	186 (149–236)	274 (252–297)	259 (238–284)	268 (242–294)	268 (242–294)	243 (219–266)	227 (204–248)	240 (216–265)	262 (240–287)
		7–10 years		196 (148–226)	276 (248–297)	263 (241–285)	272 (249–295)	272 (249–295)	241 (217–263)	225 (202–249)	237 (214–263)	258 (234–286)
		11–17 years		192 (156–234)	273 (254–295)	262 (242–289)	272 (253–295)	272 (253–295)	241 (224–262)	222 (203–244)	233 (212–252)	258 (237–282)
Eriksson et al. [36]	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	–	NA	204 ± 19	282 ± 14	270 ± 13	281 ± 12	281 ± 15	245 ± 12	231 ± 13	239 ± 14	263 ± 15
Tariq et al. [15]	Stratus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	Caucasian	NA	200.8 (SD NA)	NA	NA	NA	NA	NA	NA	NA	NA
		East Asian		191.8 (SD NA)								
		South Asian		188.4 (SD NA)								
		Middle Eastern		194.1 (SD NA)								
Zhang et al. [37]	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	–	250.6 ± 11.5	178.5 ± 15.6	267.7 ± 13.7	257.1 ± 13.0	261.1 ± 13.5	260.4 ± 14.7	241.7 ± 12.8	223.3 ± 12.8	234.2 ± 13.9	259.2 ± 13.8
		Boys	252.0 ± 11.5	181.1 ± 15.3	269.5 ± 14.3	259.6 ± 12.4	264.0 ± 13.8	264.2 ± 14.3	241.4 ± 12.5	224.0 ± 12.4	233.5 ± 13.5	258.9 ± 13.5
		Girls	249.4 ± 11.4	176.2 ± 15.5	266.2 ± 12.9	254.9 ± 13.2	258.6 ± 12.8	257.1 ± 14.3	242.1 ± 13.1	222.1 ± 13.1	234.9 ± 14.2	259.6 ± 14.1
		6 years old	252.2 ± 9.9	175.8 ± 14.4	268.2 ± 12.4	257.8 ± 10.7	260.8 ± 11.5	259.3 ± 11.9	244.2 ± 11.5	226.7 ± 12.3	238.8 ± 13.7	262.1 ± 12.1
		7 years old	250.8 ± 11.3	176.4 ± 14.0	267.9 ± 13.3	256.5 ± 12.7	260.0 ± 14.1	260.2 ± 16.0	242.4 ± 12.1	223.7 ± 12.4	235.5 ± 12.8	260.5 ± 13.0
		8 years old	251.1 ± 11.9	180.6 ± 15.7	268.0 ± 13.8	257.6 ± 12.5	261.3 ± 13.2	261.1 ± 14.7	242.0 ± 12.4	223.6 ± 12.3	235.5 ± 14.6	259.9 ± 14.8
		9 years old	250.4 ± 12.4	178.9 ± 16.0	267.4 ± 15.0	257.7 ± 12.6	262.0 ± 14.3	260.7 ± 15.4	241.2 ± 14.2	222.1 ± 12.4	233.3 ± 14.4	258.8 ± 15.4
		10 years old	249.5 ± 10.5	178.8 ± 16.1	267.4 ± 12.7	256.9 ± 12.5	260.2 ± 13.4	260.1 ± 14.2	240.2 ± 11.9	222.1 ± 13.3	231.5 ± 12.7	257.5 ± 12.4
		≥ 11 years old:	250.3 ± 13.1	180.1 ± 16.6	267.7 ± 15.0	255.8 ± 17.7	263.1 ± 14.3	261.0 ± 16.1	241.7 ± 14.7	222.8 ± 14.1	232.7 ± 14.9	257.7 ±
		Hyperopia	253.3 ± 11.0	177.6 ± 14.5	270.2 ± 13.4	258.5 ± 11.7	261.6 ± 12.5	262.0 ± 14.6	245.0 ± 12.4	227.1 ± 12.1	239.3 ± 13.9	262.6 ± 13.7
		Emmetropia	252.2 ± 10.8	177.8 ± 14.8	268.9 ± 13.5	258.7 ± 13.9	262.9 ± 13.5	262.1 ± 13.3	243.1 ± 12.2	224.8 ± 11.7	235.8 ± 12.4	261.1 ± 13.3
		Low myopia	247.3 ± 11.4	178.8 ± 16.5	265.1 ± 13.1	254.8 ± 12.5	258.7 ± 14.3	257.5 ± 15.9	238.2 ± 12.7	219.1 ± 12.2	229.7 ± 13.1	255.4 ± 13.2
		Moderate to high myopia	246.6 ± 12.4	184.5 ± 18.1	263.5 ± 15.3	253.4 ± 13.5	261.5 ± 12.8	258.5 ± 14.7	237.6 ± 14.1	219.0 ± 17.7	226.1 ± 15.8	253.6 ± 14.5
Tariq et al. [86]	Stratus OCT 3 (Carl Zeiss Meditec, Dublin, CA, USA)	Birth weight (g):										
		<2500	NA	197.8 (SD NA)	NA	NA	NA	NA	NA	NA	NA	NA
		2500–4000		193.7 (SD NA)								
		>4000		192.7 (SD NA)								
		Gestational duration (weeks):	NA	207.9 (SD NA)	NA	NA	NA	NA	NA	NA	NA	NA
		≤32		197.0 (SD NA)								
		33–36		193.3 (SD NA)								
		≥37										

Table 4 (continued)

Authors and year	OCT equipment	Classification	Mean macular thickness (Mean ± SD or Mean and 5th–95th percentile, µm)	A1 (Mean ± SD or Mean and 5th–95th percentile, µm)	A2 (Mean ± SD or Mean and 5th–95th percentile, µm)	A3 (Mean ± SD or Mean and 5th–95th percentile, µm)	A4 (Mean ± SD or Mean and 5th–95th percentile, µm)	A5 (Mean ± SD or Mean and 5th–95th percentile, µm)	A6 (Mean ± SD or Mean and 5th–95th percentile, µm)	A7 (Mean ± SD or Mean and 5th–95th percentile, µm)	A8 (Mean ± SD or Mean and 5th–95th percentile, µm)	A9 (Mean ± SD or Mean and 5th–95th percentile, µm)
Spectral domain OCT												
Barrio-Barrio et al. [25]	Cirrus OCT	4–7 years	281.5(253–304)	246.3 (209.3–273)	311.6 (273.6–344)	307.9 (278.1–337)	313.9 (279.2–342)	320 (287.1–347.9)	295.7 (262.1–334)	269.3 (243–305.8)	281 (252.6–313.6)	302 (269.2–327.9)
	(Carl Zeiss Meditec, Dublin,	8–12 years	284.1 (260–309.7)	255.5 (224.5–291.7)	319 (284–344.2)	311.9 (287.5–339.5)	321.1 (295–349.3)	325.9 (302.2–354.7)	290.3 (260.1–321.6)	267.7 (243.5–291.9)	278.1 (252.2–307.3)	302 (272.9–335.4)
	CA, USA)	13–17 years	285.4 (264.9–310)	260.5 (229–286.7)	322.8 (283.8–356.6)	313.3 (282.2–346.2)	322.7 (294.9–353.2)	329 (301.3–362.8)	289.2 (265.4–318.1)	266.6 (241.5–298.2)	274.6 (250.4–321.2)	304.8 (277.2–335.4)
Altemir et al. [70]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	RE LE	282.61 (SD NA) 282.31 (SD NA)	NA	NA	NA	NA	NA	NA	NA	NA	NA
Katiyar et al. [51]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	–	NA	234.9 ± 18.6	308.7 ± 19.5	297 ± 15.5	306.9 ± 17.6	312.6 ± 18.6	274.5 ± 17.7	253.9 ± 14.7	260.8 ± 16.8	292.6 ± 20
Al-Haddad et al. [27]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	6–9 years	277 (250–296)	244 (204–284)	315 (288–344)	304 (276–328)	313 (290–336)	315 (291–338)	283 (256–311)	261 (237–288)	268 (245–298)	295 (271–317)
		9–12 years	278 (260–297)	243 (205–262)	318 (290–340)	306 (279–331)	315 (286–339)	317 (282–339)	279 (262–299)	260 (241–279)	267 (248–288)	297 (272–316)
		12–15 years	281 (257–304)	255 (223–288)	327 (303–356)	313 (289–342)	324 (301–350)	327 (304–358)	285 (259–321)	269 (241–339)	257 (255–301)	303 (278–328)
		15–18 years	283 (263–306)	259 (226–296)	329 (301–355)	314 (281–340)	321 (295–346)	329 (308–361)	284 (288–300)	265 (243–288)	268 (246–291)	300 (272–327)
Chen et al. [61]	Cirrus HD-OCT (Carl Zeiss Meditec, Dublin, CA, USA)	Emmetropia	NA	235.22 ± 19.39	319.4 ± 17.95	306.3 ± 17.16	314.3 ± 16.44	313.7 ± 27.81	284.3 ± 14.82	268.3 ± 13.69	269.5 ± 12.14	302.9 ± 14.56
		Low myopia	NA	240.93 ± 17.35	317.7 ± 14.87	302.6 ± 14.29	313.1 ± 14.72	319.1 ± 14.59	283.5 ± 13.03	263.1 ± 13.00	268.8 ± 15.64	299.4 ± 14.42
		Moderate to high myopia	NA	244.13 ± 22.26	315.5 ± 19.37	301.9 ± 18.52	307.8 ± 18.09	315.3 ± 21.06	278.1 ± 24.85	258.1 ± 14.00	260.8 ± 13.46	293.4 ± 16.24
Queiros et al. [28]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	–	282.26 ± 11.59	250.35 ± 19.28	320.31 ± 14.36	305.87 ± 14.15	316.55 ± 14.38	321.38 ± 14.99	283.25 ± 13.18	263.09 ± 12.34	273.01 ± 14.4	300.29 ± 14.33
Molnar et al. [38]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	–	289 ± 13	255 ± 17	330 ± 16	316 ± 16	325 ± 16	330 ± 17	290 ± 15	273 ± 14	277 ± 14	307 ± 15
Sushil et al. [39]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	Male	241.9 ± 22.7	249.2 ± 19.3	315.2 ± 31.5	303.1 ± 23.1	312 ± 30.3	316.1 ± 24.7	277.4 ± 12.1	258.1 ± 32	268.9 ± 11.6	292.8 ± 17.9
		Female	239.7 ± 23	239.8 ± 23.6	308 ± 22	296.8 ± 18.5	307.1 ± 17.1	311.4 ± 20.5	276.4 ± 14.5	256.4 ± 14.2	264.3 ± 15	295.1 ± 19.3
Guragac et al. [29]	Cirrus OCT (Carl Zeiss Meditec, Dublin, CA, USA)	3–6 years	279 (257–299)	236 (209–267)	314 (287–332)	302 (282–324)	311 (289–329)	314 (292–336)	284 (256–309)	262 (241–284)	272 (249–295)	299 (276–320)
		7–11 years	278 (256–301)	246 (211–277)	318 (294–342)	305 (284–324)	315 (292–335)	318 (295–343)	280 (253–308)	260 (235–279)	269 (246–292)	297 (269–329)
		12–17 years	280 (258–302)	249 (215–280)	323 (300–346)	309 (283–329)	319 (296–343)	323 (297–346)	280 (255–304)	261 (239–281)	270 (245–291)	301 (275–325)
Bueno-Gimeno et al. [77]	Cirrus HD-OCT (Carl Zeiss Meditec, Dublin, CA, USA)	Myopia	275.52 ± 30.6	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Emmetropia	282.9 ± 12.37									
		Hyperopia	287.74 ± 14.4									
		AL < 22 mm	288.8 ± 13.9	NA	NA	NA	NA	NA	NA	NA	NA	NA
		AL 22–25 mm	280.9 ± 24.11									
		AL > 25 mm	274.36 ± 13.5									
Nigam et al. [40]	Cirrus HD-OCT (Carl Zeiss Meditec, Dublin, CA, USA)	RE	114.88 ± 14.7	NA	NA	NA	NA	NA	NA	NA	NA	NA
		LE	113.9 ± 15.62									
		Male	114.7 ± 14.52	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Female	113.81 ± 15.9									
		5–9 years	NA	235.5 ± 18.78	306.6 ± 17.47	293.4 ± 16.97	306.7 ± 17.1	311.3 ± 17.02	270.3 ± 17.94	257 ± 25.6	267.1 ± 29.72	295.1 ± 18.6
		10–13 years		237.1 ± 18.24	309.1 ± 18.07	299.1 ± 16.07	308.1 ± 17.84	314.5 ± 17.15	274.1 ± 18.54	260.1 ± 26.64	265.1 ± 29.68	298.1 ± 19.28
		14–17 years		240.1 ± 18.69	312.05 ± 18.4	301 ± 16.07	308.6 ± 17.81	316.2 ± 17.72	275 ± 18.54	261 ± 26.6	267.1 ± 30.72	300 ± 19.3
Turk et al. [30]	Spectralis OCT (Heidelberg Engineering, Dossenheim, Germany)	Male	329.07 ± 13.27	262.11 ± 17.6	338.26 ± 15.69	323.94 ± 14.8	334.6 ± 15.83	329.42 ± 17.1	345.49 ± 15.9	333.47 ± 13.6	344.55 ± 14.9	349.75 ± 15.7
		Female	323.86 ± 14.57	255.15 ± 16.22	333.13 ± 17.5	317.78 ± 15.2	327.33 ± 17.4	321.07 ± 18.9	343.17 ± 15.3	329.28 ± 14.8	341.69 ± 16.4	346.13 ± 15.5

Table 4 (continued)

Authors and year	OCT equipment	Classification	Mean macular thickness (Mean ± SD or Mean and 5th–95th percentile, µm)	A1 (Mean ± SD or Mean and 5th–95th percentile, µm)	A2 (Mean ± SD or Mean and 5th–95th percentile, µm)	A3 (Mean ± SD or Mean and 5th–95th percentile, µm)	A4 (Mean ± SD or Mean and 5th–95th percentile, µm)	A5 (Mean ± SD or Mean and 5th–95th percentile, µm)	A6 (Mean ± SD or Mean and 5th–95th percentile, µm)	A7 (Mean ± SD or Mean and 5th–95th percentile, µm)	A8 (Mean ± SD or Mean and 5th–95th percentile, µm)	A9 (Mean ± SD or Mean and 5th–95th percentile, µm)
Yanni et al. [17]	Spectralis OCT (Heidelberg Engineering, Vista, CA, USA)	Male	NA	274.1 ± 2.5	349.3 ± 1.8	335.9 ± 1.8	338.4 ± 2.1	340.4 ± 2.1	NA	NA	NA	NA
		Female		267 ± 3.3	342.8 ± 3.0	326.0 ± 2.9	326.2 ± 3.8	326.8 ± 3.9				
Lee et al. [88]	Spectralis OCT (Heidelberg Engineering, Carlsbad, CA, USA)	Myopia	NA	280.8 ± 56.6	NA	324.6 ± 46.8	NA	320.5 ± 39.7	NA	NA	NA	NA
		Emmetropia		259.5 ± 28.2		319.1 ± 32.3		267.1 ± 55.7				
		Hyperopia		337.4 ± 27.3		398.8 ± 40.6		334.9 ± 42.5				
Perez-Garcia et al. [31]	Spectralis OCT (Heidelberg Engineering, Dossenheim, Germany)	–	NA	263.69 ± 4.54	345.34 ± 2.29	330.85 ± 2.17	341.52 ± 2.23	344.45 ± 2.3	303.13 ± 2.18	289.83 ± 2.31	293.77 ± 2.32	319.86 ± 2.4
Sultan et al. [80]	Spectralis OCT (Heidelberg Engineering, Heidelberg, Germany)	High myopia	NA	193.15 (SD NA)	206.49 (SD NA)	194.35 (SD NA)	209.82 (SD NA)	211.55 (SD NA)	238.59 (SD NA)	224.59 (SD NA)	237.29 (SD NA)	232.89 (SD NA)
		Control group	NA	163.9 (SD NA)	249.66 (SD NA)	231.47 (SD NA)	243.02 (SD NA)	265.29 (SD NA)	276.75 (SD NA)	264.38 (SD NA)	274.93 (SD NA)	266.11 (SD NA)
Passani et al. [54]	Spectralis OCT (Heidelberg Engineering, Dossenheim, Germany)	–	NA	274.96 ± 18.2	344.15 ± 13.6	331.55 ± 12.6	341.51 ± 15.4	346.22 ± 14.2	312.89 ± 15.6	288.00 ± 14.4	297.90 ± 18.3	316.86 ± 17.7
Rotruck et al. [18]	Portable HRA + OCT Spectralis (investigational device)	–	NA	233.7 ± 27.76	330.0 ± 12.02	313.9 ± 12.24	326.1 ± 11.79	325.1 ± 14.47	301.2 ± 11.46	287.4 ± 11.3	295.0 ± 10.77	318.0 ± 11.94
Yabas Kiziloglu et al. [34]	iVue 100 (Optovue, Fremont, CA, USA)	–	NA	257.4 ± 22.1	313.5 ± 13.9	299.6 ± 15.5	307.8 ± 15.0	316.0 ± 15.5	288.7 ± 13.9	280.1 ± 13.8	285.1 ± 15.3	301.7 ± 15.3
Ali et al. [44]	Triton Plus OCT (3D DRI OCT Triton, Topcon Corporation, Tokyo, Japan)	–	276.41 ± 17.8	225.26 ± 20.79	309.5 ± 13.86	295.2 ± 14.39	30.6.3 ± 14.6	307.1 ± 19.9	270.7 ± 19.12	256.7 ± 13.7	263.06 ± 19.1	289.15 ± 35.9

AL axial length, *SD* standard deviation.

A1 = Central macula; A2 = Superior inner sector; A3 = Temporal inner sector; A4 = Inferior inner sector; A5 = Nasal inner sector; A6 = Superior outer sector; A7 = Temporal outer sector; A8 = Inferior outer sector; A9 = Nasal outer sector.

reports from the paediatric studies because of differences in sampling and imaging techniques.

Influence of age on OCT parameters

Several papers reported no significant association between age and RNFL thickness [9, 17, 18, 20–35] or macular thickness [34, 36–44] in the paediatric population.

However, Salchow et al. [45], Lee et al. [46] and Ali et al. [44] found a statistically significant effect of age on RNFL thickness, Hong et al. [47] reported that ocular magnification —corrected average RNFL thickness was positively correlated with age, whereas Goh et al. [48] demonstrated a negative correlation between superior sector RNFL thickness and age, and Chen et al. [49] reported that for the children aged >11 almost all RNFL parameters decrease with age.

For the macular area, there was a high variability of studied parameters and some studies found a correlation between age and the thickness of some of the ETDRS sectors either for total retinal thickness or segmented retinal layers' thickness [11, 17, 18, 25, 27, 28, 31, 42, 44, 50–55], but these results were inconstant.

The need for an aged-matched normative database in adults is given by the presence of the so-called "age-related loss" for several parameters. For example, a linear decrease of average RNFL thickness was reported and the results suggest that the reduction of RNFL is pronounced after the age of 50, and the RNFL quadrants are not equally affected [56].

The majority of the studies included in our qualitative analysis showed no association between age and OCT parameters, while the results of the papers which did report a correlation are variable. Until further evidence is available, we find reasonable to consider that in the paediatric population there is no effect of age on RNFL thickness.

However, the macular thickness may vary with age: histologic studies show that most of the morphological development of the human macula takes place in the first 5 years of life and research performed with handheld OCT devices for this age range show a progressive macular thickening, with a logarithmic increase of the photoreceptor layer and a decrease in the ganglion cell and inner nuclear layers [18, 57]. The majority of the studies included in our evaluation did not include children under the age of 5, and to the best of our knowledge, there is no paper with participants covering the entire range 0–18 years of age.

Rotruck et al. [18] reported the RNFL thickness for the 0–5 years old range and the OCT examination was performed with a portable Spectralis device. The results are similar with those reported by Yanni et al. [17] for children aged between 5 and 15, using a Spectralis table-mounted OCT device (see Table 3). This finding suggests that the peripapillary RNFL thickness does not vary in parallel with the changing morphology of the macula.

Handheld OCT devices

Portable OCT devices are a good alternative to the table-mounted instruments for the examination of young, anxious or autistic children, even though unsteady hands of the examiner or the excessive motion of the child may influence the quality of the acquired images. However, the examination can also be performed under general anaesthesia [1]. Four out of the five studies included in our review which employed a handheld device used nonstandard OCT parameters (Table 2).

Influence of gender on OCT parameters

For the RNFL thickness, 18 studies found no significant difference between boys and girls [2, 17, 18, 20, 22–25, 27–29, 32, 44, 45, 50, 58–60].

Huynh et al. [12] found greater values of average RNFL, inferior sector RNFL, and 6, 12, and 9 o'clock RNFL sectors in boys, while Chen et al. [49] reported similar results for the inferior and temporal RNFL sectors. However, Zhu et al. [33] found girls to have higher thicknesses for the same inferior and temporal RNFL sectors.

For the macular OCT assessment, no correlation with gender was found by Eriksson et al. [36], Galdos et al. [52], Molnar et al. [38], Sushil et al. [39], Nigam et al. [40], and Yanni et al. [17]. A greater number of studies reported higher values in boys for different macular parameters: Huynh et al. [11]—inferior macular quadrant, Zhang et al. [37]—foveal minimum, central macula, inner ring, temporal outer quadrant, Barrio-Barrio et al. [25]—central macula, Katiyar et al. [51]—central macula and inner ETDRS ring, Al-Haddad et al. [27]—central macula, Chen et al. [61]—central macula, Queiros et al. [28]—central macula and inner ring, Guragac et al. [29]—fovea, Read et al. [41]—total macular thickness, Passani et al. [54]—inner macula volumes, Yabas Kiziloglu et al. [34]—central macula, inner ring, inferior outer quadrant, Ali et al. [44]—macular volume, central macular thickness, inferior quadrants, and temporal outer quadrant. There were no studies reporting greater values of macular OCT parameters in girls.

Based on the reported results, we draw the conclusion that RNFL thickness is not influenced by gender in the paediatric population, although the central macular OCT parameters tend to be higher in boys. These results are in agreement with the findings in the adult population [62–66].

Influence of eye laterality on OCT parameters

The average RNFL thickness presented no significant differences between the right and left eye in the studies of Ahn et al. [20], Salchow et al. [45], Leung et al. [21], Larsson

et al. [22], Rao et al. [26], Al-Haddad et al. [67], Rotruck et al. [18], Chen et al. [49], and Ali et al. [44].

However, greater values in the right eye were reported as follows: Queiros et al. [28] and Pawar et al. [59]—temporal RNFL quadrant, and Dave et al. [68]—temporal superior, nasal superior, and temporal RNFL sectors.

Other results show higher values of RNFL parameters in the left eye: Qian et al. [69]—for the thicknesses of superior and nasal RNFL sectors, Queiros et al. [28]—superior RNFL quadrant, and Pawar et al. [59]—superior RNFL quadrant.

Few studies assessed the differences between the maculae of the right and the left eye or between the dominant and nondominant eye, and the results showed no statistically significant differences [28, 38, 40].

Altemir et al. [70] recommended that the interocular differences in average RNFL thickness should not exceed 13 µm, and the differences in the macular thickness should not measure more than 23 µm.

The average RNFL thickness and the macular thickness did not show differences between the right and the left eye, but the temporal sector of RNFL was thicker in the right eye, whereas the superior sector of RNFL was thicker in the left eye. These findings imply that in future research either eye can be randomly chosen if the average RNFL or macular thicknesses are studied, but for the sectorial RNFL thicknesses the difference between the right and the left eye should be considered.

Influence of the ISNT rule on OCT parameters

The order of decreasing thicknesses of the RNFL quadrants (i.e., I = inferior, S = superior, N = nasal, T = temporal) was reported as follows:

(1) I > S > N > T: Salchow et al. [45], Elia et al. [24], Al-Haddad et al. [27], Queiros et al. [28], Pawar et al. [59], Larsson et al. [2], Gama et al. [71], Rotruck et al. [18], Bhoiwala et al. [72], and Ali et al. [44].
(2) S > I > N > T: Huynh et al. [12], Pawar et al. [23], Rao et al. [26], and Yanni et al. [17].
(3) S > I > T > N: Ahn et al. [20], Leung et al. [21], Larsson et al. [22], Qian et al. [69], Chen et al. [49], and Zhu et al. [33].
(4) I > S > T > N: Turk et al. [30], Perez-Garcia et al. [31], Tsai et al. [73], and Kang et al. [60].

Dave et al. [74] also reported the prevalence of the rule in their participants: I > S > N > T (23.8%); I > S > T (52.4%); S > I (45.2%); T > N (50%).

The ISNT rule was first described on optic disc photographs for the neuroretinal rim thicknesses [75], and it was reported that the eyes of patients with glaucoma do not follow this rule. Later OCT studies also investigated the ISNT rule for the sectorial RNFL thicknesses, mostly in adults [74].

As shown, the results reported by studies conducted on paediatric participants demonstrate high variability, so the disobedience of the ISNT rule cannot be interpreted as abnormal.

Influence of spherical equivalent and ocular axial length on OCT parameters

A positive correlation between spherical equivalent of refractive error and average RNFL thickness was observed in several studies: Salchow et al. [45], Huynh et al. [12], Jun and Lee [76], Qian et al. [69], Tas et al. [58], Pawar et al. [23], Barrio-Barrio et al. [25], Rao et al. [26], Al-Haddad et al. [27], Queiros et al. [28], Bueno-Gimeno et al. [77], Lee et al. [46], Eslami et al. [32], Tsai et al. [73], Chen et al. [49], Zhu et al. [33], Kang et al. [60], and Ayala and Ntoula [35]. A few papers found no correlation between spherical equivalent and average RNFL thickness: Goh et al. [48], Larsson et al. [2], Gama et al. [71], and Ali et al. [44].

No significant effect of refractive error on optic nerve head parameters was found, as reported by Samarawickrama et al. [78], Patel et al. [8], Bueno-Gimeno et al. [77], Larsson et al. [2], and Ali et al. [44].

For the macular region, a positive correlation between spherical equivalent and various regional OCT parameters was observed [25, 29, 34, 37, 42–44, 48, 52, 54, 77, 79, 80]. On the other hand, Queiros et al. [28] and Sultan et al. [80] found a negative correlation with central macular thickness, whereas Molnar et al. [38] and Gama et al. [71] found no correlation at all with the investigated macular parameters.

The majority of papers investigating the possible association between ocular axial length and average RNFL thickness observed a negative correlation: Huynh et al. [12], Jun and Lee [76], Leung et al. [21], Tas et al. [58], Rao et al. [26], Oner et al. [81], Bueno-Gimeno et al. [77], Lee et al. [46], Aykut et al. [82], Chen et al. [49], Zhu et al. [33], Kang et al. [60], and Ali et al. [44]. Two studies found no correlation with average RNFL thickness [9, 48].

For the macular OCT parameters, three types of results were obtained:

(1) Positive correlation: Huynh et al. [11] and Bueno-Gimeno et al. [77]—for central macular thickness; Goh et al. [48]—for the ganglion cell—inner plexiform layer thickness; Ali et al. [44]—for the thickness of the temporal outer sector.
(2) Negative correlation: Luo et al. [79]—for total macular volume, and outer and inner macular volume; Galdos et al. [52] and Totan et al. [53]—for the ganglion cell—inner plexiform layer thickness;

Guragac et al. [29] and Bueno-Gimeno et al. [77]—for the average macular thickness and volume; Yabas Kiziloglu et al. [34]—for the thicknesses of the temporal, inferior and nasal outer macular sectors; Ali et al. [44]—for the thicknesses of the superior and inferior inner sectors.

(3) No correlation: Lim et al. [9]—for the ganglion cell complex volume; Barrio-Barrio et al. [25]—total macular thickness; Lee et al. [43]—for the ganglion cell—inner plexiform layer thickness; Ali et al. [44]—for the macular volume, average macular volume, central macular thickness.

A positive correlation between spherical equivalent of refractive error and RNFL thickness was observed by the majority of papers, whereas the measurements of optic nerve head parameters (e.g., optic disc size, and cup/disc ratio) did not correlate with the spherical equivalent. Inconsistent results were reported for the macular parameters, and also for the relation between OCT results and ocular axial length.

Ocular magnification effect was incriminated to affect these results: the distance between the instrument and the examined tissue can vary from eye to eye and thus influence the measurements. However, the magnification effect may exert influence only on the lateral measurements, i.e. the measurements made parallel to the retinal plane, which eventually affect the calculation of area or volume [83, 84]. The axial measurements (e.g., macular thickness evaluation) should not be influenced by this optical effect [84]. For the RNFL assessment, the thickness measurement itself is not affected by the ocular magnification, but the distance between the scanning circle and the optic nerve head can vary: all the OCT devices use a predefined diameter of the scanning circle, so the RNFL thickness values can indirectly be influenced by this effect.

The great variability of the results reported in the evaluated papers is given by the various methodologies employed: some authors included adjustments for ocular magnification (e.g., Bueno-Gimeno et al. [77], and Read et al. [41]), whereas other authors did not (e.g., Bhoiwala et al. [72] and Sultan et al. [80]). Moreover, there is debate between those who used a correction for ocular magnification on which formula is better to be used [49].

However, the presentation of differences between OCT instruments and the review of physical principles behind the ocular magnification effect are beyond the scope of this paper. What is relevant from the clinician's point of view is that the ocular magnification effect can influence the lateral measurements in the child's growing eye and the issue is not yet fully addressed by the OCT manufacturers.

Limitations of our review

We did not take into consideration the studies assessing the choroid thickness, the OCT angiography studies, or the papers in which anterior segment OCT was employed. We chose to include only the posterior pole OCT examinations because these are the most frequently used in the clinical practice.

The minimum number of participants enroled in the studies to be included in this analysis was arbitrarily chosen. To the best of our knowledge, there is no consensus regarding the minimum number of participants (or eyes) enroled for the study of the normal range values of the OCT parameters. However, the total number of participants for each study included in this review can be found in Table 2.

Conclusions

The general conclusions of our analysis on the normal OCT results in the paediatric population are:

(1) Average RNFL thickness is not influenced by age, gender, or eye laterality.
(2) Macular thickness should be considered separately for children aged <5 and children aged >5.
(3) Central macular thickness has a tendency towards higher values in boys.
(4) Temporal RNFL sector is thicker in the right eye.
(5) Superior RNFL sector is thicker in the left eye.
(6) Macular thickness is not significantly different between the right and the left eye.
(7) The ISNT rule is not necessarily valid.
(8) RNFL thickness increases as the spherical equivalent of refractive error increases.
(9) The optic nerve head OCT parameters are not influenced by the refractive error.
(10) Ocular axial length can have an effect on the ocular magnification, and thus influence the lateral OCT measurements.
(11) Handheld OCT devices are a good alternative for young or uncooperative children.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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