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Rebecca E Leighton, Karen M M Breslin, Kathryn J Saunders and Sara J McCullough
Centre for Optometry and Vision Science, School of Biomedical Sciences, Ulster University, Coleraine, UK

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Correspondence: Rebecca E Leighton
E-mail address: leighton-r@ulster.ac.uk

Abstract

Purpose: To evaluate the repeatability and reproducibility of the swept-source optical coherence tomographer Zeiss IOLMaster 700 and compare its outputs with those obtained using partial coherence interferometry (Zeiss IOLMaster v3) in a healthy, paediatric population.

Methods: This is a cross-sectional, observational study. Examiner 1 took two sets of biometric measurements (axial length [AL], mean corneal radius of curvature [K_{mean}], anterior chamber depth [ACD] and lens thickness [LT]) from right eyes using the IOLMaster 700, and one set of measurements (AL, K_{mean} and ACD) using the IOLMaster v3. Examiner 2 took one full set of measurements using the IOLMaster 700. Mean differences and 95% limits of agreement (LOA) were calculated, and Bland and Altman plots used to explore repeatability and reproducibility of the IOLMaster 700 alongside establishing its agreement with the IOLMaster v3.

Results: Mean participant age was 7.52±0.58 years. Repeatability analyses demonstrated small mean differences and narrow 95% LOA for AL (0.001mm, -0.013mm to 0.015mm), K_{mean} (0.002mm, -0.020mm to 0.024mm), ACD (-0.003mm, -0.031mm to 0.024mm) and LT (0.001mm, -0.024mm to 0.026mm) respectively. Similarly, small mean differences and narrow 95% LOA established excellent reproducibility (AL 0.001mm, -0.016mm to 0.018mm; K_{mean} -0.001mm, -0.027mm to 0.025mm; ACD -0.010mm, -0.041mm to 0.021mm; LT 0.002mm, -0.016mm to 0.020mm). The IOLMaster 700 and IOLMaster v3 demonstrated good agreement with small mean differences and narrow 95% LOA (AL 0.009mm, -0.034mm to 0.052mm; K_{mean} 0.016mm, -0.013mm to 0.044mm; ACD 0.134mm, 0.055mm to 0.212mm).

Conclusions: When used within a paediatric population, these data demonstrate the IOLMaster 700 to be highly repeatable and reproducible for measures of AL, K_{mean}, ACD and LT. There is excellent inter-instrument agreement between the IOLMaster 700 and IOLMaster v3 for measures of AL and K_{mean}. ACD measurements show weaker agreement. These data will be useful to inform reports from population-based studies of refractive error and clinical myopia research.

Key Points

- The IOLMaster 700 is highly repeatable and reproducible for measures of ocular biometry in children under cycloplegia.

- The IOLMaster 700 demonstrates higher levels of repeatability and reproducibility for measures of lens thickness and anterior chamber depth in cyclopleged children compared to those not under cycloplegia.
- Researchers and clinicians can be assured that the IOLMaster 700 and IOLMaster v3 demonstrate excellent agreement for measures of axial length and radius of corneal curvature in children.

Introduction

The IOLMaster (Carl Zeiss Meditec AG, Jena, Germany) is considered the gold standard optical biometer.[1,2] Although most commonly used for calculating intraocular lens power prior to cataract surgery and refractive lens exchange, its non-invasive nature lends it for use in studies of childhood refractive error,[3,4] with a strong correlation reported between axial length (AL) and spherical equivalent refraction.[5–7] Axial length, alongside refractive error, is one of the primary outcome measures used to monitor myopia progression during clinical trials.[8] Furthermore, considering the risk of visual impairment due to myopia related comorbidities significantly rises with increasing axial length, this parameter can be useful in monitoring the status of ocular health.[9]

Excellent repeatability has been demonstrated among both adults and children using earlier versions of the IOLMaster[10–12] which uses partial coherence interferometry (PCI) to measure axial length, keratometry for corneal radius of curvature measurement and image analysis to gauge anterior chamber depth. Repeatability refers to the variation in repeat measurements made on the same subject under identical conditions i.e., the same instrument and examiner, whereas reproducibility refers to the variation in measurements made on the same subject under different conditions, such as changing the examiner.[13]

The newly developed IOLMaster 700 uses swept-source optical coherence tomography (SS-OCT) technology to measure axial biometrics including axial length, central corneal thickness, anterior chamber depth and lens thickness. This modern technology allows for faster scanning speeds compared to previous models. The IOLMaster 700 incorporates an infrared laser to facilitate a deeper range of imaging and higher scan resolution than PCI.[14]

Numerous publications have established the IOLMaster 700 to have good repeatability and reproducibility among both healthy adults and older individuals with cataract.[14–23] However, publications evaluating this device in a paediatric population are scarce.[24] To date, there has been no published report of the repeatability and reproducibility of the IOLMaster 700 among children under cycloplegia.

Good inter-instrument agreement between the IOLMaster 700 and several other commercial optical biometers has been established,[14–19,22,24] but so far no publications have described its level of agreement with the IOLMaster v3. In addition, aside from Huang *et al.*,[24] all of these inter-instrument studies are limited to adult subjects.

With clinical myopia research among children increasing worldwide, repeatable and reproduceable measures of axial length are required to accurately monitor myopic progression. Due to size and structural differences between child and adult eyes, for example child eyes may be smaller and the lens will likely be clearer than adult eyes, it is important to evaluate the IOLMaster 700 in children rather than generalising findings from previous adult studies. Furthermore, children may be less cooperative than adults which could impact on measurement variability.[25–27]

The present study aims to evaluate the repeatability and the reproducibility of biometric measurements taken by the IOLMaster 700 alongside establishing how well the IOLMaster 700 measures agree with those taken by the IOLMaster v3 in a paediatric population under cycloplegia.

Methods

Participants

Participants were randomly selected children aged 6-8 years taking part in The Northern Ireland Childhood Errors of Refraction (NICER) Study 2.0; a cross-sectional, epidemiological study of white UK children's refractive error which commenced in 2018. Informed written parental consent and written participant assent were obtained prior to data collection. The study was approved by Ulster University Research Ethics Committee and adhered to the tenets of the Declaration of Helsinki.

Sample size was determined using the power calculation for agreement between two methods with a desired confidence interval of 0.01mm (step size of the instruments) and a standard deviation of 0.02mm.[16,28]

Study Instrumentation

The IOLMaster v3

The IOLMaster v3 is a non-invasive computerised device that uses the principle of PCI to measure AL. A signal to noise ratio value for AL readings is automatically calculated with the manufacturer recommendation of the use of measurements with a signal to noise ratio value of two or greater. Image analysis of a slit lamp system is used to measure anterior chamber depth (ACD). Similarly, image analysis of a six-point telecentric keratometry technique is used for corneal radius of curvature measurement. An iris image captured by this device gives an optional white-to-white measurement.

The IOLMaster 700

The IOLMaster 700 is also a non-invasive device which uses SS-OCT technology for axial biometry measurements including AL, central corneal thickness, ACD and lens thickness (LT). An infrared laser (1050nm) facilitates a deeper range of imaging and higher scan resolution compared with older models. SS-OCT technology achieves faster scanning speeds, with a full eye-length tomogram captured at 2000 A-scans per second. The IOLMaster 700 automatically captures multiple measurements for each biometric parameter and presents the examiner with an average. Standard deviation values are calculated with a warning presented to the examiner when measurements are of poor quality and require repetition. Like previous models, the IOLMaster 700 uses telecentric keratometry for corneal radius of curvature measurement. Image analysis of a scleral and iris image measures pupil diameter and white-to-white. The additional feature of a foveal scan allows the examiner to check for accurate fixation throughout the measurement process.

Examination Procedures

Data from paired eyes are highly correlated therefore measurements were taken from only the right eye of each participant.[28,29] Biometrics measured using both the IOLMaster 700 and the IOLMaster v3 included AL, mean corneal radius of curvature (K_{mean}) and ACD. In addition, LT was measured by the IOLMaster 700.

Data collection took place over one study visit. Cycloplegia was achieved by instilling one drop of proxymetacaine hydrochloride 0.5% followed by one drop of cyclopentolate hydrochloride 1% to both eyes. Ocular biometry was performed at least 20 minutes post cycloplegic instillation. Study instrumentation was calibrated daily prior to data collection.

For both biometry devices, participants were directed to place their head against the forehead and chin rests and fixate on the enclosed target. A study investigator gently held the child's head in place to aid the measurement process. Each child had biometric measures taken in the following order:

(1) Two sets of biometric measures, AL, K_{mean}, ACD and LT, taken by Examiner 1 using the IOLMaster 700
(2) AL, K_{mean}, and ACD taken by Examiner 1 using the IOLMaster v3
(3) AL, K_{mean}, ACD and LT taken by Examiner 2 using the IOLMaster 700

Between measures, the child briefly moved away from the biometer. The IOLMaster 700 was used in automatic capture mode, whereas the IOLMaster v3 measures were manually taken by the examiner, with the averages of five AL measurements, three keratometry measurements and five ACD measurements used for subsequent analyses. All measurements were carried out according to manufacturer guidelines.

Statistical Analysis

Statistical analyses were performed using SPSS software (IBM SPSS Statistics, version 25). Mean difference, standard deviations (SD) and 95% limits of agreement (LOA) were calculated for all average measures of AL, K_{mean}, ACD and LT. Previous publications have analysed corneal curvature using various methods.[15,21,22] The present study analysed mean corneal radius of curvature (the average of the measurements taken from the steepest and flattest corneal meridians).

In the present study, repeatability refers to measurements taken by a single examiner, while reproducibility refers to measurements taken by two separate examiners. Bland and Altman plots were used to describe both repeatability and reproducibility of the IOLMaster 700 and the level of agreement with the IOLMaster v3. Repeatability, reproducibility and agreement were assessed by calculating the difference between two measurements and the standard deviation of the difference (SD_{diff}). Bland and Altman plots present the difference between two measurements along the Y-axis and the mean of the two measurements along the X-axis.

The 95% LOA were calculated using the following equation:

$$95\%\ LOA = \text{mean difference} \pm (1.96 \times SD_{diff})$$ [30]

On the Y-axis, reference lines were included to indicate the mean difference between two measurements and the upper and lower 95% LOA. The breadth of the 95% LOA indicates the level of repeatability, reproducibility or agreement of the measurement technique of the instrument(s).

The distribution of the data was assessed using Shapiro-Wilk test with a p-value >0.05 considered normally distributed. Pearson’s correlation or its non-parametric equivalent (Spearman’s correlation) was used to determine the presence of proportional bias. A p-value <0.05 was considered statistically significant.

Results

Evaluation of the IOLMaster 700

Repeatability analyses were performed on 53 participants (mean age 7.81±0.47 years, range 6.32-8.41 years). Reliable repeat measures were unable to be obtained from four participants, hence reproducibility analyses were performed on 49 participants (92%) (mean age 7.22±0.56 years, range 6.32-8.30 years). A wide distribution of each biometric was assessed (AL range 20.93mm-24.29mm, K_{mean} range 7.12mm-8.36mm, ACD range 2.95mm-4.20mm and LT range 3.12mm-3.76mm). Mean differences, SD and 95% LOA for biometric measurements taken by the IOLMaster 700 are presented in Table 1.

Table 1. Repeatability and reproducibility of the IOLMaster 700 in children
(AL, axial length; K_{mean}, mean corneal radius of curvature; ACD, anterior chamber depth; LT, lens thickness; SD, standard deviation; LOA, limits of agreement)

	Repeatability (n=49)		**Reproducibility (n=53)**	
Biometric	**Mean Difference (SD) (mm)**	**95% LOA (mm)**	**Mean Difference (SD) (mm)**	**95% LOA (mm)**
AL	0.001 (0.007)	-0.013 to 0.015	0.001 (0.009)	-0.016 to 0.018
K_{mean}	0.002 (0.011)	-0.020 to 0.024	-0.001 (0.013)	-0.027 to 0.025
ACD	-0.003 (0.014)	-0.031 to 0.024	-0.010 (0.016)	-0.041 to 0.021
LT	0.001 (0.013)	-0.024 to 0.026	0.002 (0.009)	-0.016 to 0.020

Figures 1 and 2 show Bland and Altman plots illustrating the repeatability and reproducibility of the IOLMaster 700 respectively ((a) AL, (b) K_{mean}, (c) ACD, (d) LT)

Figure 1. Bland and Altman plots showing the repeatability of (a) axial length (AL), (b) mean corneal radius of curvature (K_{mean}), (c) anterior chamber depth (ACD) and (d) lens thickness (LT) measurements taken by the IOLMaster 700 by examiner 1. Mean difference is illustrated by a solid line, upper and lower 95% limits of agreement (LOA) by dashed lines.

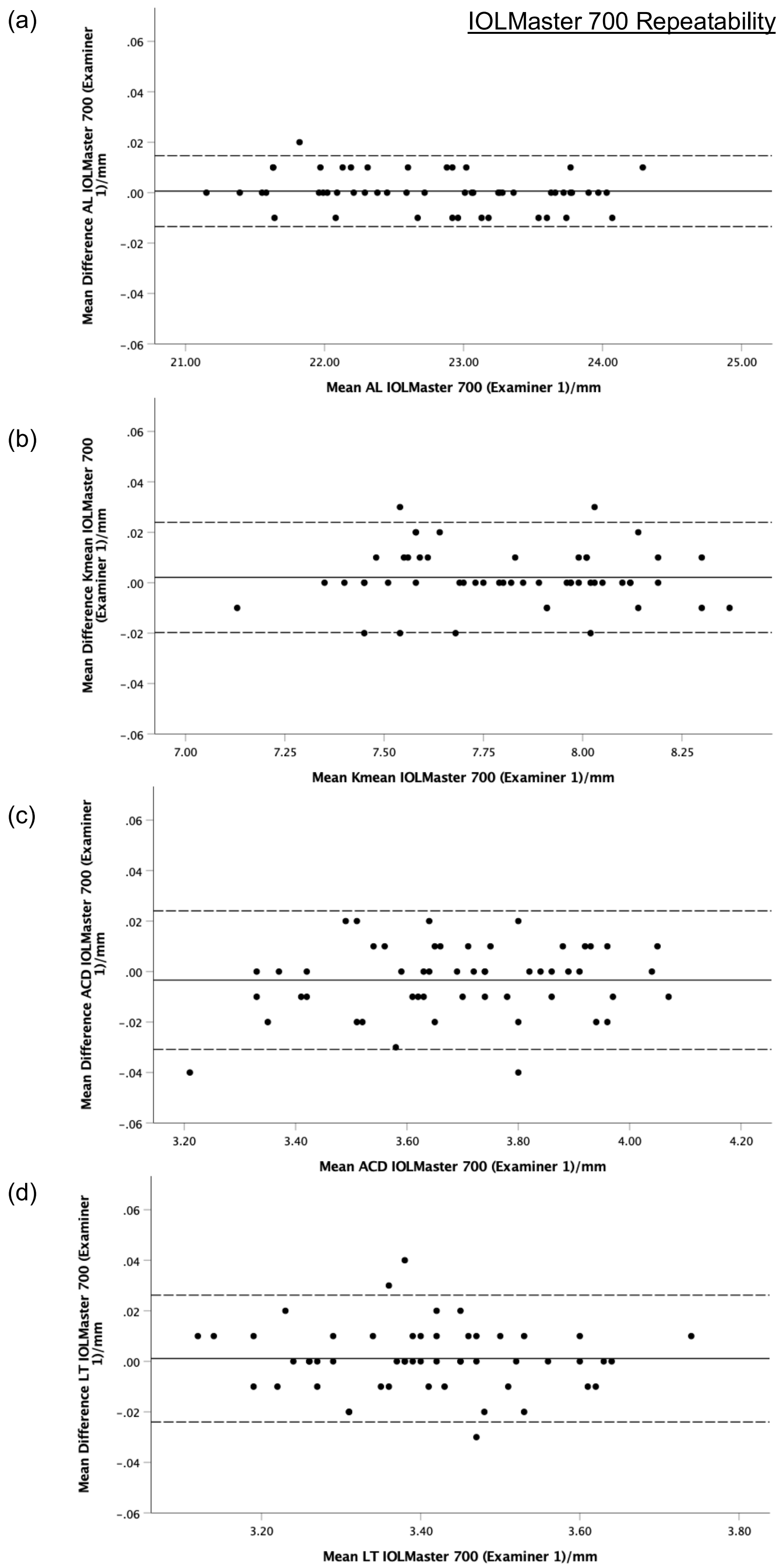
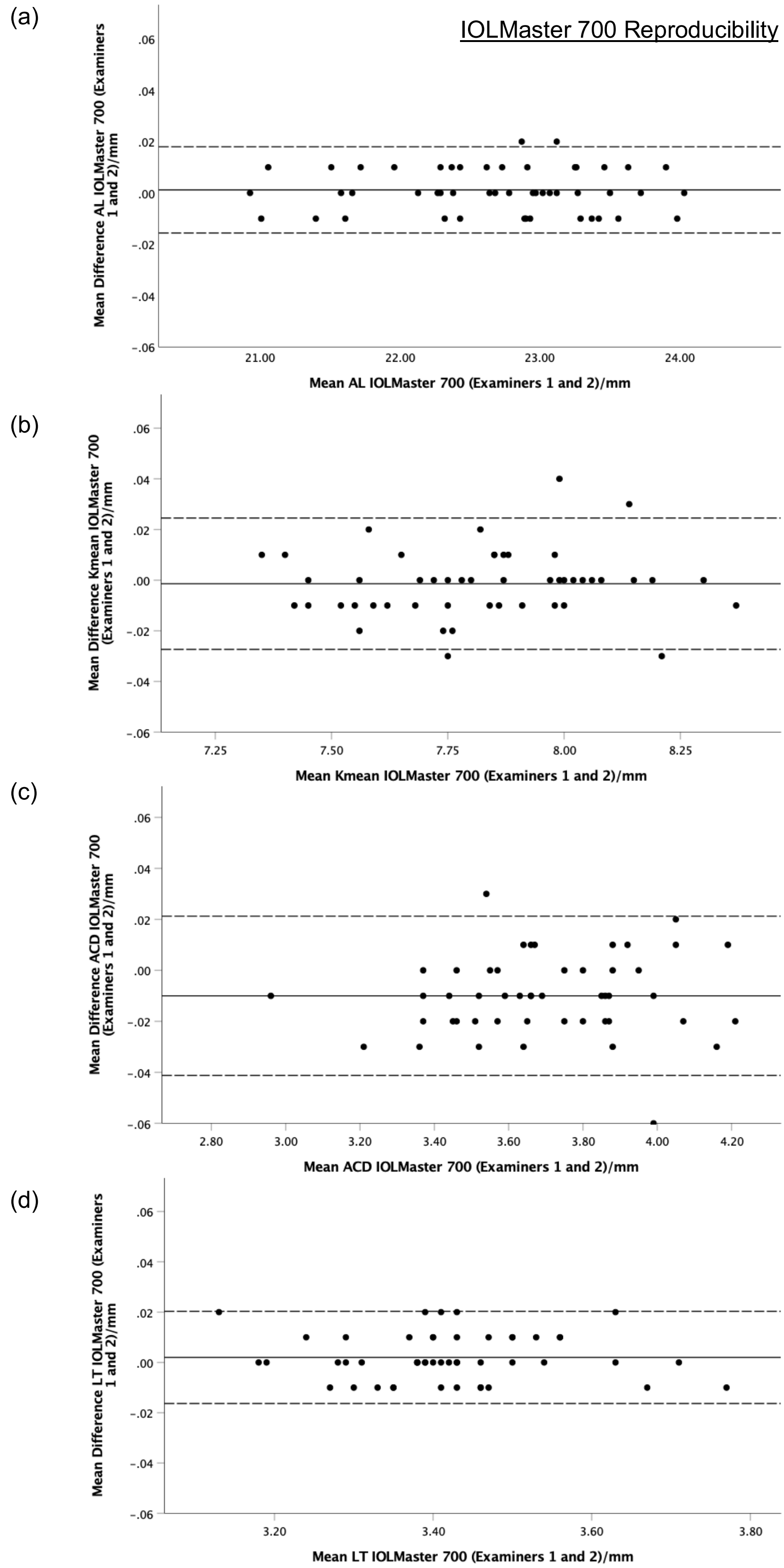


Figure 2. Bland and Altman plots showing the reproducibility of (a) axial length (AL), (b) mean corneal radius of curvature (K_{mean}), (c) anterior chamber depth (ACD) and (d) lens thickness (LT) measurements taken by the IOLMaster 700 by examiners 1 and 2. Mean difference is illustrated by a solid line, upper and lower 95% limits of agreement (LOA) by dashed lines.



Pearson's/Spearman's correlation showed no statistically significant proportional bias for any biometric parameter involved in the evaluation analyses of the IOLMaster 700 (all $p>0.11$).

Inter-Instrument Agreement Between the IOLMaster 700 and IOLMaster v3

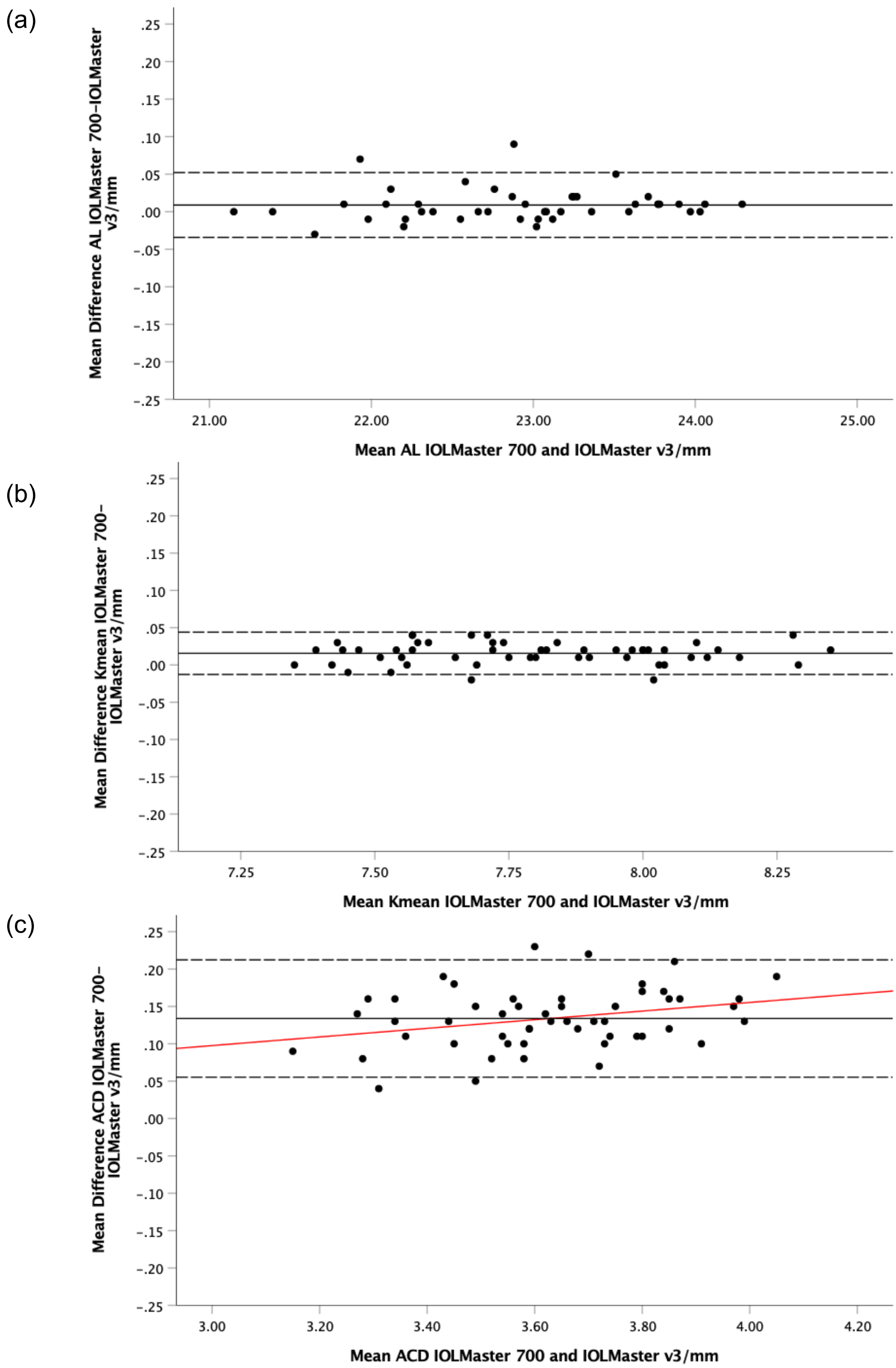
Inter-instrument agreement analyses for AL measurements were performed on 44 participants (mean age 7.75±0.50 years, range 6.32-8.41 years) for whom reliable measures of AL were obtained (83%). Reliable measures of K_{mean} and ACD were achieved in 52 participants (98%) (mean age 7.80±0.47 years, range 6.32-8.41 years) who were subsequently included in the inter-instrument agreement analyses for these parameters. Mean difference, SD and 95% LOA for inter-instrument agreement of biometric measurements taken by the IOLMaster 700 and IOLMaster v3 are presented in Table 2.

Table 2. Inter-instrument agreement of biometry measurements taken by the IOLMaster 700 and IOLMaster v3 *(AL, axial length; K_{mean}, mean corneal radius of curvature; ACD, anterior chamber depth; SD, standard deviation; LOA, limits of agreement)*

Biometric	Mean Difference (SD) (mm)	95% LOA (mm)
AL	0.009 (0.022)	-0.034 to 0.052
K_{mean}	0.016 (0.014)	-0.013 to 0.044
ACD	0.134 (0.040)	0.055 to 0.212

Figure 3 shows Bland and Altman plots illustrating the level of inter-instrument agreement of biometric parameters measured by the IOLMaster 700 and IOLMaster v3 ((a) AL, (b) K_{mean} and (c) ACD).

Figure 3. Bland and Altman plots showing the level of inter-instrument agreement for (a) axial length (AL), (b) mean corneal radius of curvature (K_{mean}) and (c) anterior chamber depth (ACD) measurements taken by the IOLMaster 700 and IOLMaster v3 by examiner 1. Mean difference is illustrated by a solid black line, upper and lower 95% limits of agreement (LOA) by dashed lines and the solid red line represents the presence of statistically significant proportional bias.



Pearson's/Spearman's correlation showed no statistically significant proportional bias present for measures of AL or K_{mean} taken by the IOLMaster 700 and IOLMaster v3 (both p>0.19). There was statistically significant proportional bias present for measures of ACD taken by these biometers (r=0.30, p=0.03). As ACD became larger, the mean difference between the measures taken by the IOLMaster 700 and IOLMaster v3 increased, with the IOLMaster v3 measuring lower than the IOLMaster 700.

Discussion

Evaluation of the IOLMaster 700

The current study investigated the repeatability and reproducibility of the IOLMaster 700 in children under cycloplegia and presents these data through limits of agreement which is considered the gold-standard approach for such comparisons.[28–30] The IOLMaster 700 was demonstrated to have excellent AL repeatability and reproducibility indicated by small mean differences of 0.001mm and narrow 95% LOA (repeatability LOA -0.013mm to 0.015mm; reproducibility LOA -0.016 to 0.018mm). These findings are consistent with a recent report by Huang *et al.*,.[24] describing the repeatability and reproducibility of this device among older Chinese children (mean age 10.37±1.81 years, range 7-14 years). Similarly, several publications including healthy adults describe the IOLMaster 700 as highly reliable for measures of AL.[20–23] In fact, Sel *et al.*,[23] reported almost identical results to the present study with a mean difference of -0.0002mm (SD 0.02) and 95% LOA of -0.005mm to 0.01mm for AL intra-examiner repeatability in adults. Although comparisons with these previous publications are limited by the different methodologies and statistical analyses used, the present study findings suggest that AL measures taken by the IOLMaster 700 are not impacted by age, nor ethnicity.

Furthermore, the current study demonstrates the SS-OCT IOLMaster 700 to have superior AL repeatability than that described for the PCI IOLMaster and A-Scan ultrasound (PCI IOLMaster 95% LOA ±0.04mm; A-Scan ultrasound 95% LOA ±0.23mm).[31]

In keeping with former reports from paediatric studies,[24] the present study established the IOLMaster 700 to have excellent repeatability and reproducibility for measures of corneal radius of curvature. Unlike the current study Huang *et al.*,[24] expressed corneal measurements in dioptres, and several other publications have described corneal radius of curvature repeatability and reproducibility in terms of the flatter and steeper corneal meridians (R1 and R1).[20,22] Both Bullimore *et al.*,[22] and Ferrer-Blasco *et al.*,[20] found repeatability limits of ≤±0.06mm for R1 and R2 among healthy adults. In addition, Bullimore *et al.*,[22] described reproducibility limits of ±0.07mm for R1 and R2. Although different statistical analyses were used by these authors, their findings compare favourably to the narrow 95% LOA calculated for K_{mean} in the present study (repeatability LOA -0.020mm to 0.024mm; reproducibility LOA -0.027mm to 0.025mm). Considering that the distribution of corneal measurements has been described using the average value of the flatter and steeper corneal meridians in several large scale studies of childhood refractive error and ocular biometry, K_{mean} was deemed a suitable definition for the present study analyses.[6,32,33]

The IOLMaster 700 has previously been evaluated among children in the absence of cycloplegia.[24] However it is widely known that accommodation substantially alters ACD and LT parameters in children. Although AL is also demonstrated to statistically significantly increase during periods of accommodation, this change is arguably clinically insignificant.[34] Studies confirm that the temporary paralyses of the ciliary muscles induced through cycloplegia results in a substantial flattening of the lens and a simultaneous increase in ACD.[35,36] Hence, it is important to consider the use of cycloplegia when measuring these ocular components. Conversely, AL measurement is reportedly unaffected by cycloplegia.[35,36]

Huang *et al*.,[24] calculated within-subject standard deviation (S_w), test-retest (TRT) repeatability, coefficients of variation (CoV) and intraclass correlation coefficients (ICC) to describe the repeatability and reproducibility of the IOLMaster 700 among a sample of non-cyclopleged children. Hence, to facilitate direct comparisons with the current population of cyclopleged children, the same reliability outcomes were calculated for measures of ACD and LT taken using the IOLMaster 700 (Table 3). These comparisons established higher levels of repeatability and reproducibility for both measures of ACD and LT in cyclopleged children. The IOLMaster 700 has also been demonstrated to have excellent repeatability for measures of ACD in healthy adults, [20,22,23] with Bullimore *et al*.,[22] reporting repeatability and reproducibility limits of ≤±0.03mm for this biometric.

Compared to the other axial biometry measurements taken by the IOLMaster 700, poorer reliability has been described for measures of LT in both adults and children.[20,24] Conversely, Bullimore *et al*.,[22] found similar repeatability and reproducibility limits for all axial parameters measured including LT. The latter study included markedly older subjects (mean age 33.7±9.2 years) with less accommodation compared to the school-aged children and younger adults (mean age 27.37±6.52 years) reported by Huang *et al*.,[24] and Ferrer-Blasco *et al*.,[20] respectively. The present study used cycloplegia to inhibit accommodation and established excellent LT repeatability and reproducibility as indicated by narrow 95% LOA (repeatability LOA -0.024mm to 0.026mm; reproducibility LOA -0.016mm to 0.020mm). Therefore, future studies aiming to accurately determine lens thickness should use a non-accommodative state, especially in younger populations and when conducting longitudinal comparisons.

There are several primary biometrics which cumulatively determine refractive error including AL, corneal curvature and LT,[37] with AL being the more important biological value relating to long-term ocular health. In myopia, axial elongation causes stretching of the globe which changes the structure and physiology of the eye and increases the risk of developing sight threatening ocular pathology.[38,39] Hence, AL measurement has important applications in monitoring ocular health status.

If the cornea and lens fail to compensate for an axial elongation of 0.05mm, this equates dioptrically to a myopic shift of approximately -0.12D which is well outside the ±0.02mm 95% LOA established within the present study and thus can be considered a 'real' change.[22,40] Considering the superior repeatability of AL measurement over refractive measures,[41] it is important to include measures of AL within myopia research, clinical trials and clinical management of myopia using myopia control methods. Furthermore, measures of AL are more precise than refractive measures alone,[8] therefore AL can reliably detect smaller changes in eye growth occurring over shorter time periods allowing refractive status to be monitored more closely and accurately.

Table 3. Reliability outcomes for measures of anterior chamber depth and lens thickness obtained using the IOLMaster 700 among a cyclopleged paediatric population in the present study and those established among a paediatric population without cycloplegia.[24]

(ACD, anterior chamber depth; LT, lens thickness; S_w, within-subject standard deviation; TRT, test-retest repeatability [2.77 S_w]; CoV, within-subject coefficient of variation; ICC, intraclass correlation coefficient)

Biometric	Study	S_w	TRT	CoV (%)	ICC (95% CI)
Intra-examiner repeatability					
ACD	Present study	0.01	0.02	0.20	0.999 (0.998-0.999)
	Huang et al., (2020)	0.01	0.04	0.40	0.996 (0.994-0.997)
LT	Present study	0.01	0.02	0.19	0.998 (0.996-0.999)
	Huang et al., (2020)	0.02	0.06	0.61	0.981 (0.974-0.987)
Inter-examiner reproducibility					
ACD	Present study	0.01	0.03	0.29	0.999 (0.996-0.999)
	Huang et al., (2020)	0.02	0.05	0.52	0.993 (0.989-0.995)
LT	Present study	0.01	0.01	0.14	0.999 (0.998-0.999)
	Huang et al., (2020)	0.03	0.07	0.75	0.969 (0.954-0.979)

Inter-instrument agreement

To date there are no publications exploring the inter-instrument agreement of biometric parameters measured by the PCI based IOLMaster v3 and its successor, the SS-OCT IOLMaster 700. This gap in the literature prevents researchers and clinicians from making informed comparisons between data collected prospectively where equipment has been replaced or updated.

A summary of previously published inter-instrument agreement data for various optical biometers, including the IOLMaster 700, is presented in Table 4. The present study established excellent agreement between these two optical biometers for measures of AL in paediatric subjects, as illustrated by a small mean difference of 0.009mm and narrow 95% LOA of -0.034mm to 0.052mm. When comparing the IOLMaster 700 with another PCI-based iteration of the IOLMaster (the 500), Huang *et al.*,[24] deemed the two to be clinically interchangeable for measures of paediatric AL. A similarly high level of agreement has been established between the IOLMaster 700 and IOLMaster 500 for AL measures in healthy adults.[22] Yu *et al.*,[42] describes agreeable measures of AL taken by two PCI based biometers, the IOLMaster v5.4 and the Nidek AL-Scan, among children. Conversely, AL measured by other SS-OCT biometers (the OA-2000 and the ARGOS) have shown weaker agreement with the PCI IOLMaster (versions 5.4 and 5) in both adults and teenagers respectively.[43,44]

The current study established superior inter-instrument agreement for measures of corneal radius of curvature in children than that reported for the IOLMaster 700 and IOLMaster 500 in adults.[22] However Bullimore et al.,[22] analysed corneal radius of curvature with respect to R1 and R2 rather than mean corneal radius of curvature.

Huang *et al.*,[45] highlighted the importance of controlling accommodation when measuring certain ocular parameters by evaluating the level of agreement between ACD measures taken by the IOLMaster v5.4 and the Lenstar LS 900 in healthy young adults (mean age 22.1±4.7 years) with and without cycloplegia. As expected, the level of agreement under non-cycloplegic conditions was poorer than under cycloplegic conditions, indicated by 95% LOA of -0.19mm to 0.20mm, and -0.11mm to 0.17mm respectively. Despite the use of cycloplegia within the present study, inter-instrument agreement analyses revealed that ACD measurements had the weakest agreement of all the biometrics studied. Wider 95% LOA of -0.053mm to 0.073mm have been reported for repeat cycloplegic ACD measurements taken by the PCI based IOLMaster.[46] The weaker reliability of the PCI IOLMaster will limit its agreement with the IOLMaster 700,[28] and helps to explain the poorer inter-device agreement for measures of ACD established by the present study. It is also important to note that the mean difference between these devices increased as the ACD became larger, with the IOLMaster v3 obtaining lower measurements than the IOLMaster 700. Similarly weaker inter-device differences have been reported for measures of ACD taken by the IOLMaster 700 and IOLMaster 500 in adults.[22]

The different technologies employed by these biometers likely contributes to the established inter-instrument difference in ACD measurements. The IOLMaster 700 uses SS-OCT technology to measure ACD, whereas the IOLMaster v3 uses image analysis of an optic section produced by a slit-illumination system. Other authors have proposed this slit-lamp system projects the slit-beam at 30 degrees temporal to the visual axis, therefore the IOLMaster v3 does not measure true axial ACD but produces a deeper off-centre reading.[11,47] This theory is not supported by the current study, which instead found the IOLMaster 700 measured a slightly deeper mean ACD of 3.69±0.22mm compared to the IOLMaster v3 mean ACD of 3.56±0.29mm. It has also been suggested that stray light and reflections may affect the image analysis of the slit-illumination system measuring ACD.[45] To combat this, several publications describe using a dimly lit room for ocular biometry measurements.[17,18,23] More simply, these differences may be the result of operator error due to the manual nature of the IOLMaster v3 and difficulties finding the exact focal position of the slit beam used to measure ACD.

Table 4. Review of previous studies evaluating the inter-instrument agreement between various optical biometers for measures of axial length (AL), corneal radius of curvature (K) and anterior chamber depth (ACD)[22,24,31,43,44,46]

(SD, standard deviation; LOA, limits of agreement; R1 and R2, corneal radius of curvature in the flatter and steeper meridian)

					AL		**K**		**ACD**	
Authors (year)	**Subjects (n)**	**Cycloplegia**	**Mean Age (SD) (years)**	**Instruments Compared**	**Mean Difference (SD) (mm)**	**95% LOA (mm)**	**Mean Difference (SD) (mm)**	**95% LOA (mm)**	**Mean Difference (SD) (mm)**	**95% LOA (mm)**
Present Study	Paediatric (52)	Yes	7.80 (0.47)	IOLMaster 700 v IOLMaster v3	0.009 (0.022)	-0.034 to 0.052	0.016 (0.014)	-0.013 to 0.044	0.134 (0.040)	0.055 to 0.212
Huang *et al*., (2020)	Paediatric (100)	No	10.37 (1.81)	IOLMaster 700 v IOLMaster 500	0.025	-0.004 to 0.054	N/A	N/A	N/A	N/A
Bullimore *et al*., (2019)	Adults (48)	No	33.7 (9.20)	IOLMaster 700 v IOLMaster 500	0.04 (0.01)	0.01 to 0.06	R1 0.01 (0.03) R2 0.01 (0.03)	R1 -0.05 to 0.08 R2 -0.05 to 0.08	-0.00 (0.07)	-0.15 to 0.15
Hussaindeen *et al*., (2018)	Paediatric (188)	No	13.88 (1.69)	ARGOS v IOLMaster v5	-0.11 (0.05)	-0.19 to -0.02	N/A	N/A	N/A	N/A
Yu *et al*., (2018)	Paediatric (58)	Yes	8.4 (1.52)	AL-Scan v IOLMaster v5.4	0.00 (0.03)	-0.05 to 0.05	N/A	N/A	0.17 (0.06)	0.05 to 0.29
Huang *et al*., (2017)	Adult (65)	No	21.71 (4.11)	OA-2000 v IOLMaster v5.4	0.01 (0.03)	-0.05 to 0.07	N/A	N/A	0.01 (0.1)	-0.19 to 0.22
Hussin *et al*., (2006)	Paediatric (20)	No	11.4	A-Scan v PCI IOLMaster	0.017 (0.108)	-0.21 to 0.21	N/A	N/A	N/A	N/A
Carkeet *et al*., (2004)	Paediatric (179)	Yes	10.60 (0.80)	Echoscan v PCI IOLMaster	0.14	-0.37 to 0.64	N/A	N/A	0.09	-0.28 to 0.46

Conclusions

In a paediatric population under cycloplegia, the SS-OCT based IOLMaster 700 demonstrated high repeatability and reproducibility for all biometrics measured. The 95% LOA reported within the current study are beneficial for clinicians and researchers involved in myopia clinical trials and research, as well as the clinical management of myopia in which AL is one of the primary outcome measures used to monitor myopia progression. Differences in AL of greater than -0.013mm to 0.015mm taken by the same examiner, and -0.020mm to 0.024mm taken by different examiners, using the IOLMaster 700 can be considered a real change in AL when performing paediatric ocular biometry. In addition, excellent agreement was established between the IOLMaster 700 and IOLMaster v3 for measures of AL and K_{mean}. Hence, these biometers can be used interchangeably when measuring these biometrics in a paediatric population. However, this approach is not recommended when measuring ACD, a parameter for which these devices' measurements demonstrated a weaker level of agreement. These data will inform prospective research and clinical myopia management where repeat measures are taken with different devices.

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DISCLOSURE

The authors report no conflicts of interest and have no proprietary interest in any of the materials mentioned in this article.

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