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Elvan Yalcin

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ORIGINAL ARTICLE

A Comparison of Refraction Defects in Childhood Measured Using Plusoptix S09, 2WIN Photorefractometer, Benchtop Autorefractometer, and Cycloplegic Retinoscopy

Elvan Yalcın[1], Pinar Sultan[2], Senay Yılmaz[1], and Ioannis G. Pallikaris[1]

[1]*Dunya Eye Hospital, Istanbul, Turkey, and* [2]*Istanbul Training and Research Hospital, Ophthalmology Department, Istanbul, Turkey*

ABSTRACT

Purpose: To compare Plusoptix (Gmbh, Nuremberg, Germany), 2WIN (Adaptica, Padua, Italy), the benchtop refractometer (Auto-Kerato-Refractometer KR-8900; Topcon Co, Tokyo, Japan), and retinoscopy with regard to the consistencies. *Materials and Methods*: In our prospective study, 200 eyes of 100 patients were included. We analyzed the demographics and characteristics of the patients, the percentage of patients from whom measurements could not be obtained, the measurements from both patients' eyes of pupil diameter, spherical, cylindrical, axis, and spherical equivalence. *Results*: The mean age ± SD was 7.8±4.5 years (range, 1–18 years). Pupil diameter measurements were found to be consistent (Cronbach's alpha value >0.8). The sphere and spherical equivalence measurements for both eyes were found to be consistent with each other in all apparatus (Cronbach's alpha value >0.8). However, consistency was found to be lower in cylindrical values and the Jackson cross-cylinder measurements at 0° and 45° axis were found to be inconsistent with each other (Cronbach's alpha value <0.8). *Conclusions*: While consistency was observed in all methods in terms of sphere and spherical equivalence, consistency dropped in cylindrical values and no consistency was observed in axis values. It is important to take this point into consideration, especially in axis measurements.

Keywords: Autorefraction, pediatric vision screening, photorefraction, refraction measurement, retinoscopy

INTRODUCTION

Ambliopia is the most common cause of decrease in sharpness of eyesight during childhood. Faults in refraction (especially anisometropia) and being cross-eyed are common causes.[1] Correct measurement of the refraction defect is very important in terms of the prevention of ambliopia. Today, various methods such as retinoscopy (static and dynamic), autorefraction, photorefraction, and visual-evoked responses are used for this purpose.[2]

Cycloplegic retinoscopy is the gold standard in the detection of defects in refraction; however, the main problems associated with it are the long learning curve and the necessity for patient cooperation. Non-mobile autorefractors may also cause difficulties in the measurement of refraction defects in young children.[3–8] The main advantages of the Plusoptix Photoscreener (Plusoptix Gmbh, Nuremberg, Germany) and 2WIN (Adaptica, Padua, Italy) photorefractors are that they are easy to carry, have an approximate 1 m working distance, measurements are obtained in a short amount of time, they provide binocular measurement, and give a measurement of the pupil diameter.[9–13] However, it must be kept in mind that autorefractors can register myopia as being higher and hypermetropia as being lower than the true measurement.[14]

In this study, we aimed to compare Plusoptix and the 2WIN hand-held refractometer, benchtop autorefractometer (Auto-Kerato-Refractometer KR-8900; Topcon Co, Tokyo, Japan), and retinoscopy with regard to their features of determining refraction defects.

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Correspondence: Pinar Sultan, M.D., Istanbul Training and Research Hospital, Kasap Ilyas Mah, Org Abdurrahman Nafiz Gurman Cd, PK 34098, Fatih, Istanbul, Turkey. E-mail: orenc_pinar@yahoo.com

MATERIALS AND METHODS

In our prospective study, 200 eyes of 100 patients aged 1–18 years were included. Our study was carried out in accordance with the Helsinki Declaration principles and an informed consent form was obtained from all patients. All patients included in the study underwent Plusoptix and 2WIN hand-held refractometry, and benchtop autorefractometer device and cycloplegic retinoscopy refraction measurements. Patients who had ocular pathologies such as pterygium, cornea disease, cataract, vitreous opacity, retina disease, strabismus, and nystagmus, which could affect measurement, and those who had had an eye operation in the past for any reason were excluded from the study.

The Plusoptix includes a small portable, infrared camera that can be mounted on a computer. Refraction is measured by directing the patient's fixation toward the mobile camera, in 0.8 seconds and from a distance of one meter. The device can simultaneously calculate the refraction measurements for both eyes and the numeric values for corneal reflex, pupil size, and interpupillary distance. The spherical and cylindrical measurement range is between –7.00D and 5.00D. The measurement results are indicated as red (unreliable) and green (reliable). Results outside the measurement range are indicated as "hyperopia" or "myopia." If, after several attempts, the device was unable to obtain a picture to provide a computer printout result, the tester made the notation, "unable to obtain reading."

The 2WIN photo-refractometer can carry out binocular or monocular measurements. The spherical and cylindrical measurement range is between –5.00D and 5.00D. The measurement results are indicated as red (unreliable) and green (reliable). Just like Plusoptix, the 2WIN device can simultaneously calculate the refraction measurements and numeric values for corneal reflex, pupil size, and interpupillary distance. Results outside the measurement range are indicated as "hyperopia" or "myopia." If, after several attempts, the device was unable to obtain a picture to provide a computer printout result, the tester made the notation, "unable to obtain reading."

The table-top autorefractometer (Auto-Kerato-Refractometer KR-8900; Topcon Co, Tokyo, Japan), on the other hand, can measure small pupils (minimum 2 mm) through the use of Rotary Prism Technology. It decreases accommodation with the auto-fogging system. The spherical measurement range is between +22D and –25D, and the cylindrical measurement range is between +10D and –10D. Five measurements were taken automatically and the most appropriate one was indicated.

All patients were given a detailed eye examination, including the front and rear segments. The refraction defects of all eyes were measured in a quiet room using Plusoptix, 2WIN and the benchtop refractometer, first without and then with cycloplegia. After cycloplegia, cyclopegic retinoscopy was performed using a streak retinoscope under the same conditions.

Cycloplegia was obtained with two drops of cyclopentolate 0.5% (one year of age) or 1.0%, administered by a nurse. Forty minutes after the drops were administered, cycloplegic retinsocopy (Welch Allyn Elite Retinoscope, Welch Allyn Inc., NY, USA) was carried out by an experienced ophthalmologist who was not informed of the results of the refractometry.

The measurements carried out with a benchtop refractometer were taken after the patients positioned their chins and foreheads in the slot in the device. Active children were held still by their family members for a short while during the measurement. In measurements carried out with Plusoptix and 2WIN, the measurements were taken by positioning the devices' hand-held camera level with the patient's eyes, from a distance of 1 m.

In the calculation of the spherical equivalence, the following formula was used:

Spherical equivalence (dioptria (D)) = Spherical value (D) + [Cylindrical value(D)/2].

The axis component was converted into a vector representation for analysis:

Jackson cross-cylinder at axis 0° with power J0 = -(cylinder/2) cos(2Xaxis); Jackson cross-cylinder at axis 45° with power J45 = -(cylinder/2) sin(2Xaxis).[15]

The fixation gradation was conducted as temporal, nasal, hypo, and hyper. Temporal and nasal gradation was further categorized as 1, 2, 3 within each gradation. For phasing, the distance between the center of the pupil and the edge of the pupil was divided into three parts. The fixation closest to the center of the pupil was taken as phase 1; the furthest fixation was taken as phase 3.

We analyzed the demographics and characteristics of the patients, the percentage of patients from whom measurements could not be obtained, and the average of three achieved measurements from the patients' right and left eyes of pupil diameter, degree of fixation, spherical, cylindrical, axis, and spherical equivalence.

The age and refraction defect values obtained from the study groups are presented as average ± standard deviation. Reliability statistics were used to investigate the consistency of sphere, cylinder, axis, spherical equivalence, and Jackson's cross-cylinder measurements using Plusoptix, 2WIN, KR-8900 before and after the drops, and which measurement was most consistent with the retinoscope after the drops. Cronbach's alpha values more than 0.8 were considered to be consistent.

RESULTS

Two hundred eyes of 100 patients with an average age of 7.8±4.5 years (range, 1–18 years) were included. The minimum, maximum, and mean values (± SD) of pupil diameter, spherical, spherical equivalent, cylindrical power, axis, J0 and J45 using Plusoptix S09, 2WIN, KR-800 before and after cycloplegia and retinoscopy after cycloplegia are showed in Tables 1, 2, 3, and 4.

Although measurements could not be taken from a total of nine (4.5%) eyes before cycloplegia with 2WIN, a result indicating hypermetropia was obtained in four eyes and myopia in one eye. Measurements could not be taken from a total of 23 eyes after cycloplegia (11.5%); however, a result of hypermetropia was obtained in 10 eyes.

TABLE 1. The minimum, maximum, and mean values (± SD) of pupil diameter, spherical, spherical equivalent, cylindrical power, axis, J0 and J45 using Plusoptix S09 before and after cycloplegia.

Plusoptix S09	Minimum	Maximum	Mean	Std. Deviation
PDR	3.60	7.50	5.8479	.79457
PDL	4.00	7.40	5.8125	.72246
SphereR	−4.50	5.50	1.4235	1.54256
CylinderR	−6.00	1.50	−.9913	1.18969
J0R	−1.68	1.93	.0400	.45350
J45R	−1.62	2.97	−.0132	.61585
AXİSR	.00	180.00	95.3721	69.36401
SER	−5.00	15.00	1.0380	2.17508
SphereL	−2.75	5.50	1.2292	1.35115
CylinderL	−6.50	1.25	−1.0952	1.30909
J0L	−1.47	1.71	.0062	.51704
J45L	−3.12	2.76	.0337	.68086
AxisL	.00	180.00	78.8493	72.42562
SEL	−3.25	4.50	.6981	1.42673
SphereRD	−3.00	5.00	1.9057	1.23336
CylinderRD	−5.00	.00	−1.1230	1.07201
J0RD	−.95	.91	.0106	.36954
J45RD	−1.92	2.48	.0360	.67110
AxisRD	.00	180.00	103.5902	66.70417
SERD	−3.62	4.87	1.3295	1.25482
SphereLD	−2.25	4.00	1.7705	1.37787
CylinderLD	−4.00	.00	−1.1066	.98896
J0LD	−1.61	1.52	−.0477	.48677
J45LD	−1.50	1.44	−.0137	.57128
AxisLD	.00	180.00	90.9508	71.43515
SELD	−3.75	3.62	1.3507	1.25886

PDR: Right eye pupil diameter; PDL: Left eye pupil diameter.

SphereR: Sphere value of the right eye; CylinderR: Cylinder value of the right eye; J0R: Jackson cross-cylinder measurements at 0°axis of the right eye; J45R: Jackson cross-cylinder measurements at 45°axis of the right eye; AxisR: Axis value of the right eye; SER: Spherical equivalent of the right eye.

SphereL: Sphere value of the left eye; CylinderL: Cylinder value of the left eye; J0L: Jackson cross-cylinder measurements at 0°axis of the left eye; J45L: Jackson cross-cylinder measurements at 45°axis of the left eye; AxisL: Axis value of the left eye; SEL: Spherical equivalent of the left eye.

SphereRD: Sphere value of the right eye after cycloplegia; CylinderRD: Cylinder value of the right eye after cycloplegia; J0RD: Jackson cross-cylinder measurements at 0°axis of the right eye after cycloplegia; J45RD: Jackson cross-cylinder measurements at 45°axis of the right eye after cycloplegia; AxisRD: Axis value of the right eye after cycloplegia; SERD: Spherical equivalent of the right eye after cycloplegia.

SphereLD: Sphere value of the left eye after cycloplegia; CylinderLD: Cylinder value of the left eye after cycloplegia; J0LD: Jackson cross-cylinder measurements at 0°axis of the left eye after cycloplegia; J45LD: Jackson cross-cylinder measurements at 45°axis of the left eye after cycloplegia; AxisLD: Axis value of the left eye after cycloplegia; SELD: Spherical equivalent of the left eye after cycloplegia.

TABLE 2. The minimum, maximum, and mean values (± SD) of pupil diameter, spherical, spherical equivalent, cylindrical power, axis, J0 and J45 using 2WIN before and after cycloplegia.

2WIN	Minimum	Maximum	Mean	Std. Deviation
PDR	4.20	8.40	6.5355	.85768
PDL	4.40	8.40	6.5260	.81372
SphereR	−7.25	40.00	.5897	1.92389
CylinderR	−5.75	4.25	−1.0435	1.28099
J0R	−2.75	2.70	−.0442	.55195
J45R	−1.60	2.12	−.0217	.61510
AXİSR	.00	.180	81.57	71.624
SER	−7.37	5.37	.1300	2.01983
SphereL	−7.25	4.50	.5372	2.17048
CylinderL	−5.75	4.00	−1.0403	1.28552
J0L	−.84	2.85	.0910	.58344
J45L	−2.87	1.30	−.1213	.56481
AxisL	.00	180.00	95.2688	72.65600
SEL	−7.75	5.25	−.0106	2.29558
SphereRD	−7.00	3.00	.6197	2.02611
CylinderRD	−6.00	.00	−.9718	.97793
J0RD	−1.36	1.27	.0052	.45390
J45RD	−2.72	1.37	−.0007	.51554
AxisRD	.00	180.00	80.3803	74.95339
SERD	−7.37	2.62	.0693	2.09824
SphereLD	−7.00	2.75	.4893	2.19660
CylinderLD	−6.50	1.60	−.9600	1.12361
J0LD	−1.98	1.81	.0030	.46016
J45LD	−3.12	1.20	−.0095	.56749
AxisLD	.00	180.00	98.9714	74.47925
SELD	−7.37	2.50	−.0394	2.28055

PDR: Right eye pupil diameter; PDL: Left eye pupil diameter.

SphereR: Sphere value of the right eye; CylinderR: Cylinder value of the right eye; J0R: Jackson cross-cylinder measurements at 0°axis of the right eye; J45R: Jackson cross-cylinder measurements at 45°axis of the right eye; AxisR: Axis value of the right eye; SER: Spherical equivalent of the right eye.

SphereL: Sphere value of the left eye; CylinderL: Cylinder value of the left eye; J0L: Jackson cross-cylinder measurements at 0°axis of the left eye; J45L: Jackson cross-cylinder measurements at 45°axis of the left eye; AxisL: Axis value of the left eye; SEL: Spherical equivalent of the left eye.

SphereRD: Sphere value of the right eye after cycloplegia; CylinderRD: Cylinder value of the right eye after cycloplegia; J0RD: Jackson cross-cylinder measurements at 0°axis of the right eye after cycloplegia; J45RD: Jackson cross-cylinder measurements at 45°axis of the right eye after cycloplegia; AxisRD: Axis value of the right eye after cycloplegia; SERD: Spherical equivalent of the right eye after cycloplegia.

SphereLD: Sphere value of the left eye after cycloplegia; CylinderLD: Cylinder value of the left eye after cycloplegia; J0LD: Jackson cross-cylinder measurements at 0°axis of the left eye after cycloplegia; J45LD: Jackson cross-cylinder measurements at 45°axis of the left eye after cycloplegia; AxisLD: Axis value of the left eye after cycloplegia; SELD: Spherical equivalent of the left eye after cycloplegia.

TABLE 3. The minimum, maximum, and mean values (± SD) of pupil diameter, spherical, spherical equivalent, cylindrical power, axis, J0 and J45 using KR-8900 before and after cycloplegia.

KR-8900	Minimum	Maximum	Mean	Std. Deviation
SphereR	−14.00	7.25	.8514	3.02612
CylinderR	−5.00	.25	−1.1588	1.31611
J0R	−2.10	2.40	−.1125	.65825
J45R	−1.56	1.92	−.0913	.56460
AXİSR	.00	180.00	96.0405	74.61067
SER	−5.75	6.62	.6792	2.40398
SphereL	−8.25	14.75	1.0743	3.19801
CylinderL	−5.50	.25	−1.0980	1.22811
J0L	−2.50	1.81	−.0383	.58094
J45L	−1.92	1.60	.0528	.56796
AxisL	−.50	180.00	89.4730	73.92471
SEL	−9.37	6.87	.7625	2.79110
SphereRD	−13.50	7.50	1.4750	3.21318
CylinderRD	−5.00	.00	−.9929	1.04515
J0RD	−2.10	1.68	−.0783	.45095
J45RD	−1.48	1.92	−.0190	.55288
AxisRD	.00	180.00	87.3500	77.55061
SERD	−5.25	13.75	1.6694	2.88286
SphereLD	−6.25	7.75	1.3250	2.71448
CylinderLD	−4.50	1.75	−.9964	1.15037
J0LD	−1.85	1.81	−.0635	.56958
J45LD	−2.16	1.30	−.0293	.51551
AxisLD	.00	180.00	93.4499	72.47858
SELD	−7.25	7.75	5.1310	2.60679

SphereR: Sphere value of the right eye; CylinderR: Cylinder value of the right eye; J0R: Jackson cross-cylinder measurements at 0°axis of the right eye; J45R: Jackson cross-cylinder measurements at 45°axis of the right eye; AxisR: Axis value of the right eye; SER: Spherical equivalent of the right eye.

SphereL: Sphere value of the left eye; CylinderL: Cylinder value of the left eye; J0L: Jackson cross-cylinder measurements at 0°axis of the left eye; J45L: Jackson cross-cylinder measurements at 45°axis of the left eye; AxisL: Axis value of the left eye; SEL: Spherical equivalent of the left eye.

SphereRD: Sphere value of the right eye after cycloplegia; CylinderRD: Cylinder value of the right eye after cycloplegia; J0RD: Jackson cross-cylinder measurements at 0°axis of the right eye after cycloplegia; J45RD: Jackson cross-cylinder measurements at 45°axis of the right eye after cycloplegia; AxisRD: Axis value of the right eye after cycloplegia; SERD: Spherical equivalent of the right eye after cycloplegia.

SphereLD: Sphere value of the left eye after cycloplegia; CylinderLD: Cylinder value of the left eye after cycloplegia; J0LD: Jackson cross-cylinder measurements at 0°axis of the left eye after cycloplegia; J45LD: Jackson cross-cylinder measurements at 45°axis of the left eye after cycloplegia; AxisLD: Axis value of the left eye after cycloplegia; SELD: Spherical equivalent of the left eye after cycloplegia.

TABLE 4. The minimum, maximum, and mean values (± SD) of pupil diameter, spherical, spherical equivalent, cylindrical power, axis, J0 and J45 using retinoscopy after cycloplegia.

Retinoscopy	Minimum	Maximum	Mean	Std. Deviation
SphereRD	−14.00	8.00	1.8360	2.89806
CylinderRD	−4.00	4.00	−.4355	1.02741
J0RD	−.57	.61	−.0420	.17684
J45RD	−1.92	1.92	.2049	.48615
AxisRD	.00	180.00	52.3118	80.29348
SERD	−5.00	7.50	1.6570	2.42130
SphereLD	−6.00	9.00	2.0134	2.57770
CylinderLD	−3.50	3.00	−.4785	.96096
J0LD	−.95	1.33	−.0109	.25971
J45LD	−1.44	1.68	.1920	.42881
AxisLD	.00	180.00	60.8226	83.24821
SELD	−6.75	8.50	1.7772	2.63286

SphereRD: Sphere value of the right eye after cycloplegia; CylinderRD: Cylinder value of the right eye after cycloplegia; J0RD: Jackson cross-cylinder measurements at 0°axis of the right eye after cycloplegia; J45RD: Jackson cross-cylinder measurements at 45°axis of the right eye after cycloplegia; AxisRD: Axis value of the right eye after cyloplegia; SERD: Spherical equivalent of the right eye after cycloplegia.

SphereLD: Sphere value of the left eye after cycloplegia; CylinderLD: Cylinder value of the left eye after cycloplegia; J0LD: Jackson cross-cylinder measurements at 0°axis of the left eye after cycloplegia; J45LD: Jackson cross-cylinder measurements at 45°axis of the left eye after cycloplegia; AxisLD: Axis value of the left eye after cyloplegia; SELD: Spherical equivalent of the left eye after cycloplegia.

When the 2WIN device was considered in terms of fixation grade, the most common fixation for the right eye was determined to be R1T (54%) and R2T (24%), central fixation was observed at an incidence of 11%. For the left eye, although L1T (55%) and L2T (25%) were most commonly observed, central fixation was determined at an incidence of 14%.

While measurements could not be taken with Plusoptix before cycloplegia from a total of 11(5.5%) eyes, a result of hypermetropia was obtained in 14 patients, and of myopia in seven patients. Measurements could not be taken from 25 (12.5%) eyes after cycloplegia, but a result of hypermetropia was obtained in 16 patients, and myopia was determined in eight patients.

When the Plusoptix device was considered in terms of fixation grade, R1T (50%) was determined most frequently for the right eye and central fixation was observed at a rate of 33%. For the left eye, L1T (48%) was most frequently observed, and secondary frequency of central fixation was 29%.

When the Plusoptix and 2WIN devices were evaluated in terms of pupil diameter measurement, the two devices were found to be consistent with each other for right and left eyes (Cronbach's alpha 0.884).

When measurements without drops were compared, the sphere values for the right eye were found to be consistent with each of the three devices and the retinoscopy performed with drops (Cronbach's alpha 0.884); the values closest to retinoscopy were obtained using KR-8900 (Cronbach's alpha 0.962). Spherical equivalent value measurements were also observed to be consistent with each other (Cronbach's alpha 0.810) and the values closest to retinoscopy were again obtained with KR-8900 (Cronbach's alpha 0.869). When Plusoptix and 2WIN measurements were compared in terms of spherical equivalence, the values closest to retinoscopy were detected using 2WIN (Cronbach's alpha 0.843). However, this consistency was much less for cylinder values (Cronbach's alpha 0.687) and the values closest to retinoscopy were obtained using Plusoptix (Cronbach's alpha 0.559).

When axes measurements were compared, the consistency between devices was found to be low (Cronbach's alpha 0.598) and the Jackson cross-cylinder measurements at 0° axis and 45° axis were found to be inconsistent with each other (Cronbach's alpha for 0° and 45° axis were 0.247 and –0.004, respectively).

Sphere values were also found to be consistent for the left eye in the three devices and retinoscopy (Cronbach's alpha 0.845) and the values closest to retinoscopy were obtained using KR-8900 (Cronbach's alpha 0.901). Spherical equivalence measurements were also found to be consistent (Cronbach's alpha 0.910). Values closest to retinoscopy were detected using 2WIN (Cronbach's alpha 0.911).

As in the right eye, consistency was found to be lower in cylindrical values (Cronbach's alpha 0.775). Values closest to retinoscopy were again obtained with Plusoptix (Cronbach's alpha 0.643). When axes measurements were compared, consistency among the devices was found to be low (Cronbach's alpha 0.640) and the Jackson cross-cylinder measurements at the 0° and 45° axis, although higher than the right, were found to be inconsistent (Cronbach's alpha for 0° and 45° axes, were 0.524 and 0.318, respectively).

When measurements taken with drops were compared, sphere and spherical equivalence measurements for the right and left eyes were found to be consistent with each other in all apparatus (Cronbach's alpha value >0.8) and the values closest to retinoscopy in sphere and spherical equivalent measurements were yielded by 2WIN (Cronbach's alpha right eye sphere 0.930; spherical equivalent 0.946; left eye sphere 0.839; spherical equivalence 0.845). The consistency of the measurement methods in cylindrical measurements was low (Cronbach's alpha for right eye 0.777; left eye 0.779). The measurements closest to retinoscopy were obtained using KR-8900 (Cronbach's alpha 0.835). In the measurements taken with drops, as with the measurements taken without drops, all three devices and retinoscopy were observed to be inconsistent in terms of axis and Jackson cross-cylinder measurements at 0° and 45° axes (Cronbach's alpha value 0.8).

With Plusoptix, consistency with retinoscopy after drops in terms of sphere value was lower (for the right eye, Cronbach's alpha before and after drops were 0.797 and 0.672, respectively; for the left eye, Cronbach's alpha before and after drops were 0.780 and 0.680, respectively). However, the change that occurred after drops was less with 2WIN (right eye Cronbach's alpha before and after drops were 0.887 and 0.852, respectively; left eye before after drops were 0.885 and 0.849, respectively).

The Plusoptix and 2WIN devices' cylindrical measurements before and after drops were found to be consistent (Cronbach's alpha for Plusoptix 0.890; for 2WIN 0.968). However, although consistency in the 2WIN device was good for sphere values after drops, it was found to be lower in Plusoptix (Cronbach's alpha for 2WIN 0.964; for Plusoptix 0.574).

DISCUSSION

The detection of ambliopia and of high refraction defects is one of the main aims in pediatric vision screening. There is a cooperation problem with optotype-based screening, especially in the 1–3 years age group, and the measurement of refraction defects in this age group is of particular importance. It is known that the effect of ambliopia treatment after age five decreases[16]; measurement of refraction defect from a very young age is important in terms of intervention against a possible case of ambliopia. Photoscreening and autorefraction are suggested as suitable methods for vision screening in children aged 3–5 years by the United States Preventative Services Task Force (USPSTF).[17,18]

Important advances have taken place in photoscreeners and autorefractors in the last 10 years. Today, these devices present us with additional data, such as pupil diameter and ocular alignment, as well as determining refraction defects. It is possible to use many devices together and the consistency of these devices may be important. Plusoptix and 2WIN can take measurements quickly and easily with an infrared camera. In our study, consistency with photorafractometer, autorefractometer, and cycloplegic retinoscopy was investigated.

In measurements Gekeler et al. carried out with a photorefractometer, they found spherical values to be 0.43D and cylindrical values to be 0.33D more hypermetropic compared with the autorefractometer.[19] In our study, the consistency of measurements from the devices was taken as a basis, and while all spherical values were found to be consistent before and after the drops, the consistency was lower in cylindrical values.

It is known that accommodation affects the spherical equivalent value. Especially in children and in patients with high spherical power, this becomes more important. Ozdemir et al. detected a drop in cylindrical power after cycloplegia with Plusoptix A90.[9] Schimitzek et al. also obtained similar results and considered that peripheral aberrations following pupil dilation may affect measurements.[20] In our study, although cylindrical consistency was maintained before drop administration, a decrease in spherical consistency was observed.

When considered in terms of fixation grade, centralization was detected more with Plusoptix. The finding that Plusoptix was more consistent with retinoscopy compared with 2WIN in terms of cylindrical measurements taken without drops may be connected to this. However, in spherical equivalence measurements, values closer to retinoscopy were obtained using 2WIN.

Many studies have been done on Plusoptix. With the revised criteria of Matta et al., the sensitivity and specificity of the device increased.[11,13,21,22] However, sensitivity and specificity were found to be less than Plusoptix in the only study on 2WIN.[23]

In our study, these two methods were compared using after-drop retinoscopy, which is considered the gold standard, and in terms of sphere and spherical equivalence, 2WIN measured the values closest to retinoscopy, and Plusoptix recorded the values closest to retinoscopy in terms of cylindrical values.

The most important aspect of our study was the comparison of the consistencies of Plusoptix and 2WIN devices with a benchtop refractometer and retinoscopy with drops. While consistency was observed in all methods in terms of sphere and spherical equivalence, consistency dropped in cylindrical values and no consistency was observed in axis values. It is important to take this point into consideration, especially in axis measurements.

DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

REFERENCES

1. Flom MC, Neumaier RW. Prevalence of amblyopia. *Am J Optom Arch Am Acad Optom*. 1966;43:732–751.
2. Repka MX, Beck RW, Kraker RT, et al. The clinical profile of moderate amblyopia in children younger than 7 years. *Arch Ophthalmol*. 2002;120:281–287.
3. Hopkisson B, Arnold P, Bilingham B, McGarrigle M, Shribman S. Can retinoscopy be used to screen infants for amblyopia? A longitudinal study of refraction in the first year of life. *Eye* 1992;6:607–609.
4. Harvey EM, Miller JM, Wagner LK, Dobson V. Reproducibility and accuracy of measurements with a hand held autorefractor in children. *Br J Ophthalmol*. 1997;81:941–948.
5. El-Defrawy S, Clarke WN, Belec F, Pham B. Evaluation of a hand-held autorefractor in children younger than 6. *J Pediatr Ophthalmol Strabismus* 1998;35:107–109.
6. Trager MJ, Dirani M, Fan Q, et al. Testability of vision and refraction in preschoolers: The strabismus, amblyopia, and refractive error study in singaporean children. *Am J Ophthalmol*. 2009;148:235–241.
7. Cordonnier M, De Maertelaer V. Comparison between two hand-held autorefractors: The Sure-Sight and the Retinomax. *Strabismus* 2004;12:261–274.
8. Liang CL, Hung KS, Park N, Chan P, Juo SH. Comparison of measurements of refractive errors between the hand-held Retinomax and on-table autorefractors in cyclopleged and noncyclopleged children. *Am J Ophthalmol*. 2003;136:1120–1128.
9. Ozdemir O, Tunay OZ, Petricli IS, Acar DE, Erol MK. Comparison of non-cycloplegic photorefraction, cycloplegic photorefraction and cycloplegic retinoscopy in children. *Int J Ophthalmol*. 2015;8:128–131.
10. Tuncer I, Zengin MO, Karahan E. Comparison of the Retinomax handheld autorefractor versus table-top autorefractor and retinoscopy. *Int J Ophthalmol*. 2014;7:491–495.
11. Matta NS, Singman EL, Silbert DI. Performance of the Plusoptix vision screener for the detection of amblyopia risk factors in children. *J AAPOS* 2008;12:490–492.
12. Cordonnier M, Kallay O. Non-cycloplegic screening for refractive errors in children with the hand-held autorefractor Retinomax: Final results and comparison with non-cycloplegic photoscreening. *Strabismus* 2001;9:59–70.
13. Silbert DI, Matta NS, Andersen K. Plusoptix photoscreening may replace cycloplegic examination in select pediatric ophthalmology patients. *J AAPOS* 2013;17:163–165.
14. Ugurbas SC, Alpay A, Tutar H, Sagdik HM, Ugurbas, MD SH. Validation of plusoptiX S04 photoscreener as a vision screening tool in children with intellectual disability. *J AAPOS* 2011;15:476–479.
15. Touzeau O, Costantini E, Gaujoux T, Borderie V, Laroche L. Calculations of mean refraction and variation of refraction using a dioptric space. *J FR Ophthalmol*. 2010;33:659–669.
16. Holmes JM, Lazar EL, Melia BM, et al. Effect of age on response to amblyopia treatment in children. *Arch. Ophthalmol*. 2011;129:1451–1457.
17. Calonge N, Petitti DB, Curry S, et al. Vision screening for children 1 to 5 years of age: US Preventive Services Task Force Recommendation statement. *Pediatrics* 2011;127:340–346.
18. Donahue SP, Arthur B, Neely DE, Arnold RW, Silbert D, Ruben JB. Guidelines for automated preschool vision screening: A 10-year, evidence-based update. *J AAPOS* 2013;17:4–8.
19. Gekeler F, Schaeffel F, Howland HC, Wattam-Bell J. Measurement of astigmatism by automated infrared photoretinoscopy. *Optom Vis Sci*. 1997;74:472–82.
20. Schimitzek T, Lagreze WA. Accuracy of a new photorefractometer in young and adult patients. *Graefes Arch Clin Exp Ophthalmol*. 2005;243:637–645.
21. Matta NS, Singman EL, Silbert DI. Performance of the plusoptiX S04 photoscreener for the detection of amblyopia risk factors in children aged 3 to 5. *J AAPOS* 2010;14:147–9.
22. Matta NS, Singman EL, McCarus C, Matta E, Silbert DI. Screening for amblyogenic risk factors using the plusoptiX S04 photoscreener on the indigent population of Honduras. *Ophthalmology* 2010;117:1848–50.
23. Kirk S, Armitage MD, Dunn S, Arnold RW. Calibration and validation of the 2WIN photoscreener compared to the PlusoptiX S12 and the SPOT. *J Pediatr Ophthalmol Strabismus*. 2014;51:289–92.