 DOI: 10.5603/oj.100215

Refractive outcomes of table-mounted and hand-held auto-refractometers

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ABSTRACT

BACKGROUND: The purpose of this study was to compare the concordance of measurements between a table-mounted automatic auto-refractor and a portable manual auto-refractor, test the variability of inter-operator measurements, and determine the effect of the head's position on the measurements.

MATERIAL AND METHODS: A prospective study was carried out on 100 healthy eyes. Refraction was acquired with a Topcon RM-800 tabletop auto-refractometer and a Nidek HandyRef-K portable auto-refractometer. The refractive errors were compared in terms of the sphere's power, the cylinder and its axis, the spherical equivalent, and the coordinates of the astigmatism power vectors J0 and J45. Statistical analysis was performed using SPSS software version 20.

RESULTS: The average age was 31, with 3 and 71 years old extremes. Fifty-six patients were female (56%), and 52% were right eyes. No difference between the 2 devices concerning the sphere ($p = 0.09$), the cylinder ($p = 0.18$), and the spherical equivalent ($p = 0.15$) was observed. However, there is an average difference of 4° in the astigmatism axis ($p \leq 0.001$), which is insignificant if we consider the Jackson power vector J0 ($p = 0.24$) and J45 ($p = 0.85$). The position of the head tilted back does not modify the measurements with the portable refractometer. In addition, the HandyRef can be used by any unqualified person with no risk of altering the results of the measurements.

CONCLUSION: Our results show a good concordance between the measurements obtained by the two devices. They can therefore be used interchangeably.

KEY WORDS: table-mounted autorefractor; handheld autorefractor; sphere; cylinder; spherical equivalent; astigmatism; Jackson vector

Ophthalmol J 2024; Vol. 9, 136–142

INTRODUCTION

Auto-refractometers have an essential place in ophthalmology consultation to detect refractive errors. Various devices, such as conventional table-mounted auto-refractometers or portable devices, are commonly used. Although table-top auto-refractometers quickly measure refractive errors and provide valid results, they are bulky, cannot be mobilized, and are unsuitable for bedridden patients or patients with reduced mobility, nor young children [1, 2]. On the other hand, portable auto-refractometers are small, practical, and suitable for newborns, infants, bedridden patients, or those with reduced mobility, limiting their ability to sit on the examination chair.

In this study, we compared the measurements obtained using a table-mounted auto-refractometer (Topcon RM-800; Topcon Medical Systems, Inc. Japan) and a portable auto-refractometer (Nidek HandyRef-K; Nidek Co., Ltd. Japan). The main

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objective of the study is to verify if the two devices give comparable results and could, therefore, be used interchangeably. The secondary objectives are to determine the variations in the measurements of the astigmatism axis after tilting the head upwards with the portable auto-refractometer (patient sitting position, operator standing) and to specify the variability of inter-operator measurements with the portable measuring device.

MATERIAL AND METHODS

Study design

This is a prospective study involving 100 eyes of 100 patients who consulted for corrective lens prescriptions. The study was conducted in July 2022 at the 5th Military Medical-Surgical Center of Errachidia.

Patients

The inclusion criteria were as follows: all patients aged over 3 years who consulted for decreased visual acuity or for a prescription or change of glasses.

The exclusion criteria were:

patients younger than 3 years old or over 3 years old for whom refraction measurement by table-mounted auto-refractometer is not feasible (non-cooperative subjects);

patients with a refractive error that is not measurable with one or both devices (myopia or cylinder beyond the measurement ranges of the machine);

any ocular pathology at the level of the anterior or posterior segment that interferes with auto-refractometer measurements (corneal opacity, cataract, vitreous disorder).

As refractive errors in both eyes are strongly linked, and for statistical analysis to be conducted on independent variables, only refractions of one eye of each patient were used for statistical analysis. The included eye was chosen randomly, unless one of them did not meet the inclusion criteria.

Measurements

Measurements were taken using two devices:

- the manual auto-refractometer from Nidek (HandyRef-K; Nidek Co., Ltd., Japan) consists of two parts: the main body and the portable measurement device, which is wirelessly connected to the main body. It has an automatic fogging mechanism to minimize accommodation. It automatically records 10 eye measurements and provides the best result. Its measurement range is from -20.00 to +20.00 Diopters (D) for spheres and from 0 to 12 D for cylinders;
- the table-mounted auto-refractometer from Topcon (Topcon RM-800; Topcon Medical Systems, Inc., Japan). It has a measurement range from –25.00 to +22 D and from 0 to 10 D for cylinders. It uses a color slide with an automatic fogging technique;
- each participant underwent three refraction measurements performed by the ophthalmologist: one measurement using the table-mounted auto-refractometer from Topcon (Topcon RM-800; Topcon Medical Systems, Inc., Japan), then one measurement with the manual auto-refractometer from Nidek (HandyRef-K; Nidek Co., Ltd., Japan) in a simple seated position (patient and operator seated), and finally one measurement with the head tilted upward at about 45 degrees (patient seated, operator standing). In 20 of our participants, a fourth measurement was made using the manual auto-refractometer from Nidek performed by an assistant with no training in ophthalmology or knowledge of refraction (multifunctional nurse);
- for children under 12 years old, measurements were taken under systematic cycloplegia using (Cyclopentolate 10mg/ml); beyond 12 years old, cycloplegia was performed as needed.

Statistical analysis

Statistical analysis was performed using SPSS software version 20. The Kolmogorov-Smirnov test was conducted to assess the normality of the distribution of variables. Student's t-test and Wilcoxon test were used to test differences in variables. A p-value of < 0.05 was considered statistically significant. Concordance between measurements obtained by the two devices was evaluated using the Bland-Altman plot [3, 4] for each component of the power vector: spherical equivalent (SE), Jackson vertical cylinder (J0), and oblique Jackson cylinder (J45). These measurements were obtained from the sphere (S), cylinder power (C), and its axis (A) according to the formulas: $SE = S + C/2$; $J0 = –C/2Cos(2A)$; $J45 = –C/2 \sin(2A)$. The limits of the 95% confidence interval were calculated using the mean ± 1.96 standard deviation (SD).

RESULTS

Measurements were taken from 124 subjects, but 24 of them met the exclusion criteria. Thus,

Table 1. Comparison of mean values of measurements obtained by both devices

	Topcon (n = 100)	Nidek (seated position) (n = 100)	p
Sphere*	–0.89 ± 4.39	–0.93 ± 4.38	0.09
Cylinder*	–1.07 ± 0.85	–1.11 ± 0.86	0.18
Axis**	102 ± 62	106 ± 62	**< 0.001**
Spherical equivalent *	–1.42 ± 4.62	–1.47 ± 4.59	0.15
J0*	–0.07 ± 0.54	–0.01 ± 0.47	0.24
J45*	–0.05 ± 0.41	–0.03 ± 0.52	0.85

*in diopters; **in degrees; results are expressed as mean ± standard deviation

Table 2. Comparison of mean values of measurements obtained by the HandyRef-K between the straight head position and the head tilted upward position

	HandyRef-K (Straight head) (n = 100)	HandyRef-K (Titled head) (n = 100)	p
Sphere*	–0.96 ± 4.20	–0.99 ± 4.19	0.38
Cylinder*	–1.11 ± 0.86	–1.13 ± 0.89	0.35
Axis**	106 ± 62	108 ± 63	**< 0.01**
Spherical equivalent*	–1.48 ± 4.59	–1.54 ± 4.58	0.24
J0	0.01 ± 0.47	–0.04 ± 0.55	0.38
J45	–0.03 ± 0.52	0.01 ± 0.46	0.43

*in diopters; **in degrees; results are expressed as mean ± standard deviation

the total sample size in our study was 100 eyes of 100 subjects. The average age was 31 years, with extremes of 3 and 71 years. 56 patients were female (56%), and 52% were right eyes. The sphere of the studied population ranged from (–18.5D to +8D), and the cylinder ranged from (0 to –5.50 D), with a spherical equivalent between (–19.75D and +5.5D). The results obtained by both devices in the seated position are shown in Table 1.

Our results indicate no significant differences between the two devices regarding sphere power ($p = 0.09$) and cylinder ($p = 0.18$). However, the HandyRef-K tends to overestimate the cylinder's axis by an average of 4° ($p < 0.001$). However, directly comparing axes in degrees does not provide an interpretable appreciation of the statistical difference. On the one hand, a 4° difference in the axis of astigmatism, even if very statistically significant ($p < 0.001$), may not be noticeable by the patient regarding optical correction. On the other hand, it would be confusing to compare, for example, 178° and 1°; these two axes are very close but seem very different as numbers. Therefore, statistical analysis cannot be performed separately on raw cylinder powers and axes; it requires conversion into a power vector. According to Fourier, an arbitrary sphero-cylindrical power can be expressed by a spherical power (the spherical equivalent) and two crossed cylinders (Jackson), one on the axis of 0 degrees (J0) and the other at the axis of 45 degrees (J45). The power of these three components can be interpreted as the coordinates (x, y, z) of a vector representation of the power profile. This vector representation allows for a more reliable numerical and graphical analysis. According to our results, there is no difference between the two devices in terms of spherical equivalent ($p = 0.15$) and the J0 ($p = 0.24$) and J45 components ($p = 0.85$).

Table 2 compares measurements obtained by the same operator (ophthalmologist) using the HandyRef-K in the seated position with the head straight and with the head tilted upward at about 45° (patient seated, physician standing). It is noted that there is no difference between the sphere and cylinder power, spherical equivalent, J0, and J45.

The use of the portable refractometer by the assistant yielded similar results to those obtained by the physician (Tab. 3).

The agreement of measurements between the two devices is represented by Bland-Altman plots concerning the spherical equivalent (Fig. 1), the J0 vector (Fig. 2), and the J45 vector (Fig. 3). It is noted that there is a strong correlation of all these parameters, as the majority (95%) of measurements

Table 3. Comparison of mean values of measurements obtained by the ophthalmologist and the assistant using the HandyRef-K

	Ophthalmologist (n = 20)	Assistant (n = 20)	p
Sphere*	–0.32 ± 3.64	–0.31 ± 3.53	0.85
Cylinder*	–1.21 ± 0.79	–1.22 ± 0.82	0.82
Axis**	111 ± 61	114 ± 62	0.22
Spherical equivalent*	–0.89 ± 3.81	–0.86 ± 3.70	0.74
J0*	0.08 ± 0.49	0.08 ± 0.63	0.39
J45*	0.03 ± 0.54	–0.03 ± 0.40	0.68

*in diopters; **in degrees; results are expressed as mean ± standard deviation

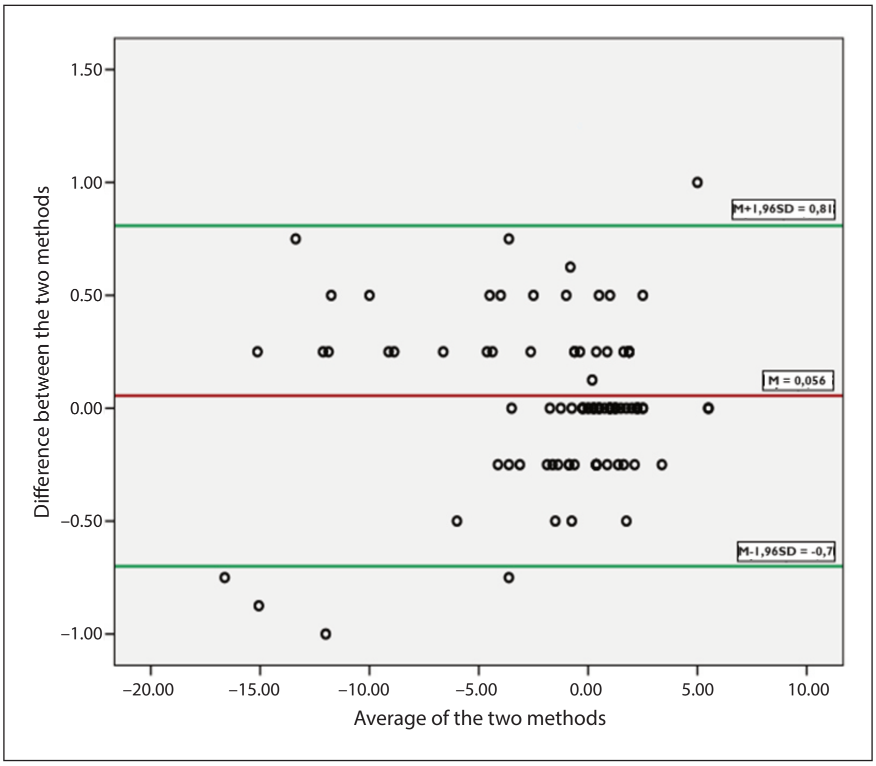

FIGURE 1. Bland-Altman plot showing the differences in spherical equivalent between the two devices. The red reference line indicates the mean. The green lines represent the 95% agreement limits

fall within the 2 limits of agreement. Therefore, the two devices can be used interchangeably.

DISCUSSION

There are few publications that have studied the validity of portable autorefractors compared to table-mounted autorefractors, and their results are not unanimous. Our study has shown that the two devices studied can be used interchangeably. Sayed et al. [2] also found a very good correlation between measurements obtained by the portable Nidek auto-refractometer (Nidek ARK-30) and the table-mounted Huvitz HRK 7000A auto-refractometer concerning all parameters of subjective refraction and could thus be used interchangeably.

However, Seymen et al. found similar results between the HandyRef-K and the table-mounted auto-refractometer (Unicos, URK-800) in terms of cylindrical power and its axis, but not in spherical equivalent [7]. Similarly, Mirzajani et al. [8] found the difference in sphere and spherical equivalent to be significant but not clinically significant. The authors attribute this difference to the large sample size studied. Arici et al. [9] and Prabakaran et al. [10] also reported a significant difference in

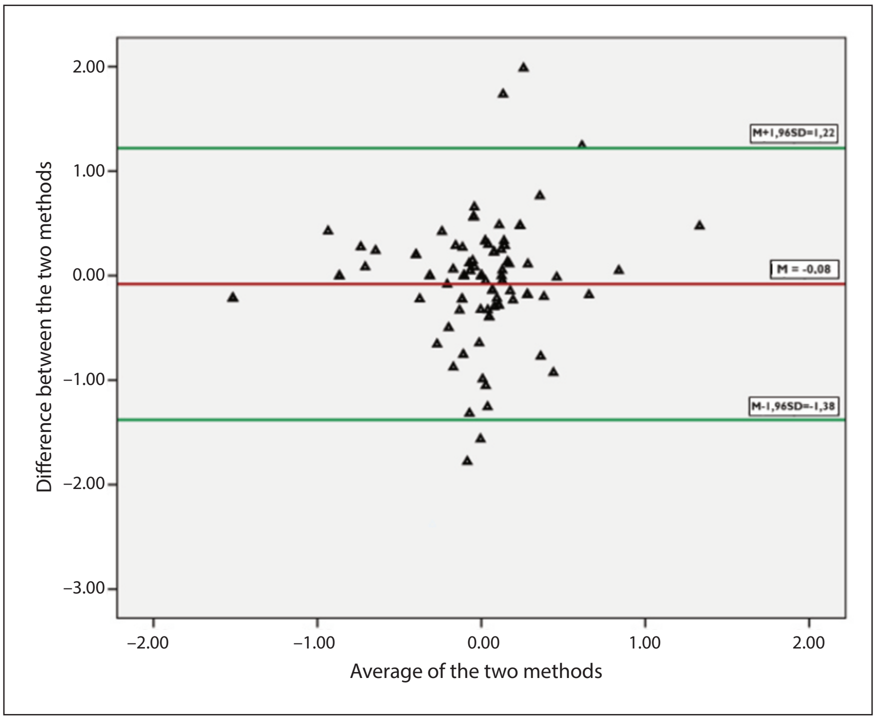

FIGURE 2. Bland-Altman plot showing the differences in J0 between the two devices. The red reference line indicates the mean. The green lines represent the 95% agreement limits

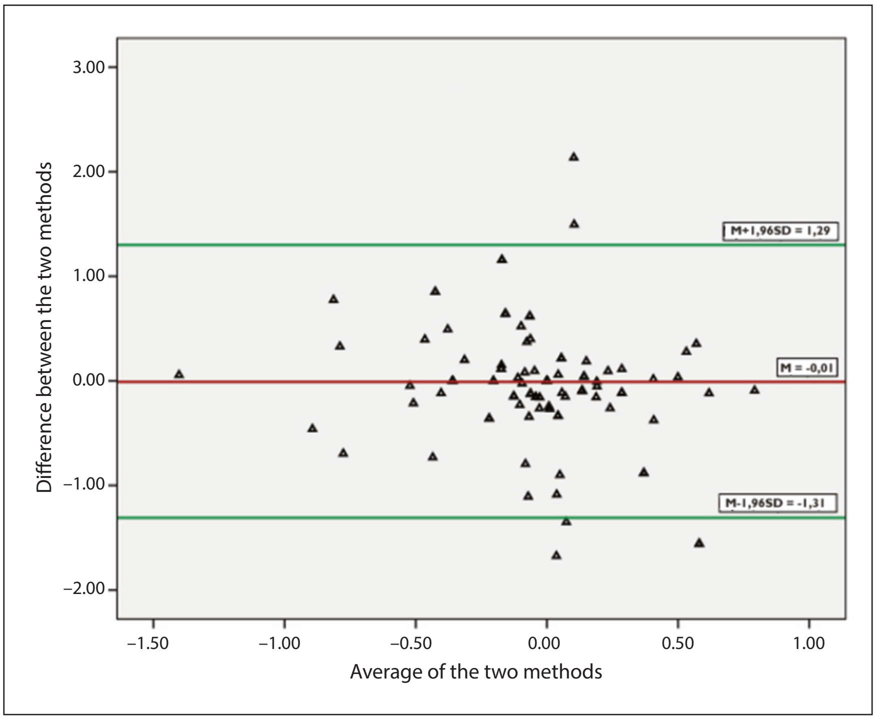

FIGURE 3. Bland-Altman plot showing the differences in J45 between the two devices. The red reference line indicates the mean. The green lines represent the 95% agreement limits

spherical and cylindrical error between portable autorefractors and table-mounted ones. This difference could be due to using a different portable device, the Retinomax. Wesemann et al. compared the Retinomax from Nikon to a conventional auto-refractometer, finding comparable results in adults and children after cycloplegia. However, results differed in children without cycloplegia [11].

Cyclotorsions occur when the eye rotates around the optical axis. They depend on head orientation. Static type occurs when the patient goes from the upright or seated position to the lying position. According to some studies, this transition induces cyclotorsion up to ±9° without being statistically significant [2, 12, 13]. In our study, we performed measurements at 45 degrees because, at 60 degrees and above, the "lying position" mode integrated into the HandyRef-K is automatically triggered and allows for astigmatism compensation. Thus, we found that the cyclotorsion between the seated position and the head tilted upward at about 45° was not significant, with a maximum amplitude of 7°. This change in axis could also be partly related to lateral micro-tilts of the head that cannot be visually controlled, unlike the table-mounted refractometer where the patient's chin and forehead are placed on a support, allowing head position control.

The portable Nidek auto-refractometer starts measurement automatically when alignment is correct; therefore, it does not require an experienced operator. Thus, it offers the advantage of being usable by a healthcare professional without any training in ophthalmology. It could be an interesting option in screening campaigns for refractive errors, such as in school environments. In our study, measurements obtained by the ophthalmologist and by a multifunctional nurse using the HandyRef-K were consistent.

Our study has some limitations. Firstly, it is a single-center study with a limited number of cases. Also, the studied population is heterogeneous, including adults and children with some measurements performed with cycloplegia and others without cycloplegia. Another limitation is that the study compared two types of commercially available autorefractors; therefore, the results cannot be extrapolated to other brands of autorefractors or other measurement technologies.

CONCLUSION

Given the good agreement between the results of both devices, the portable Nidek HandyRef-K auto-refractometer can be used interchangeably with table-mounted autorefractors to measure refractive errors, especially in screening programs, epidemiological studies, for individuals with reduced mobility or when rapid measurements are required, particularly in children or non-cooperative individuals [8]. Similarly, the portable auto-refractometer can be used by non-ophthalmology professionals, which can be advantageous in mass screenings and school settings.

Data availability

The data used to support the findings of this study are available from the corresponding author upon request.

Ethics statement

This research was conducted in accordance with the ethical principles. Every effort was made to ensure the confidentiality and privacy of the participants. Any identifying information has been anonymized.

Additionally, conflicts of interest that could potentially influence the research findings have been disclosed. No conflicts of interest exist that could be perceived as prejudicing the impartiality of this research.

Should there be any questions regarding the ethical conduct of this research, please contact the corresponding author (T.A.)

Author contributions

T.A.: design of the study, realization, data analysis, writing; M.Y.: supervision and correction; O.A.: supervision and correction.

Conflict of interest

The Authors declare that they have no conflict of interest.

Funding

None declared.

REFERENCES

1. Akil H, Keskin S, Çavdarli C. Comparison of the refractive measurements with hand-held autorefractometer, table-mounted autorefractometer and cycloplegic retinoscopy in children. Korean J Ophthalmol. 2015; 29(3): 178–184, doi: 10.3341/kjo.2015.29.3.178, indexed in Pubmed: 26028946.
2. Sayed KM, Alsmman AH, Mostafa EM. Hand-Held Nidek versus Table-Mounted Huvitz Autorefractors and Their Agreement with Subjective Refraction in Adults. Clin Ophthalmol. 2021; 15: 1391–1401, doi: 10.2147/OPTH.S263667, indexed in Pubmed: 33833497.
3. Bland JM, Altman DG. Measuring agreement in method comparison studies. Stat Methods Med Res. 1999; 8(2): 135–160, doi: 10.1177/096228029900800204, indexed in Pubmed: 10501650.
4. Bland JM, Altman D. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet. 1986;

327(8476): 307–310, doi: 10.1016/s0140-6736(86)90837-8, indexed in Pubmed: 2868172.

5. Thibos LN, Wheeler W, Horner D. Power vectors: an application of Fourier analysis to the description and statistical analysis of refractive error. Optom Vis Sci. 1997; 74(6): 367–375, doi: 10.1097/00006324-199706000-00019, indexed in Pubmed: 9255814.
6. Naeser K. Assessment and statistics of surgically induced astigmatism. Acta Ophthalmol. 2008; 86 Suppl 1: 5–28, doi: 10.1111/j.1755-3768.2008.01234.x, indexed in Pubmed: 18373792.
7. Seymen z, Bekmez S, Eris E, et al. Comparison of Refractive Disorders in Adulthood Measured by Using HandyRef-K, Retinomax, PlusOptix and Table Top Autorefractometer. Beyoglu Eye J. 2021; 6(2): 108–114, doi: 10.14744/bej.2021.28247, indexed in Pubmed: 35005503.
8. Mirzajani A, Qasemi F, Asharlous A, et al. Are the results of handheld auto-refractometer as valid as the result of table-mounted refractometer? J Curr Ophthalmol. 2019; 31(3): 305–311, doi: 10.1016/j.joco.2018.10.012, indexed in Pubmed: 31528766.
9. Arici C, Turk A, Keskin S, et al. Effect of cycloplegia on refractive errors measured with three different refractometers in school-age children. Turk J Med Sci. 2012; 42(4): 657–665, doi: 10.3906/sag-1104-44.
10. Prabakaran S, Dirani M, Chia A, et al. Cycloplegic refraction in preschool children: comparisons between the hand-held autorefractor, table-mounted autorefractor and retinoscopy. Ophthalmic Physiol Opt. 2009; 29(4): 422–426, doi: 10.1111/j.1475-1313.2008.00616.x, indexed in Pubmed: 19523087.
11. Wesemann W, Dick B. Accuracy and accommodation capability of a handheld autorefractor. J Cataract Refract Surg. 2000; 26(1): 62–70, doi: 10.1016/s0886-3350(99)00325-9, indexed in Pubmed: 10646148.
12. Lehnert R, Müller M, Liekfeld A. [Supine cyclotorsion and asphericity]. Klin Monbl Augenheilkd. 2007, 224(8):664-669.; 224(8): 664–669, doi: 10.1055/s-2007-963360, indexed in Pubmed: 17717784.
13. Smith EM, Talamo JH. Cyclotorsion in the seated and supine patient. J Cataract Refract Surg. 1995; 21(4): 402–403, doi: 10.1016/s0886-3350(13)80528-7, indexed in Pubmed: 8523282.