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Agreement between Methods of Retinoscopy, Conventional Subjective Refraction and Fogging Subjective Refraction

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ABSTRACT

Introduction: To compare the refractive error measurements achieved through three distinct techniques: retinoscopy, subjective method, and the subjective fogging method.
Methods: Participants included 223 young adults aged 18 to 36 years (mean age: 25.63±5.31). The refractive error of one eye was measured under three different accommodation control conditions: subjective refraction, fogging subjective refraction and retinoscopy.
Results: Data were collected for 223 young adults. The average spherical value obtained by the retinoscopy method was 0.21 D, and the average cylinder was -0.76 D. These values were -0.01 D and -0.75 D, respectively, in the subjective with fog method. The spherical value and cylinder obtained by the regular subjective method were -0.13 D and -0.74 D, respectively. The mean spherical equivalent with subjective refraction method was more minus than fogging subjective refraction, and retinoscopy provided the most plus results. The difference in spherical and spherical equivalent value between three methods was significant ($p < 0.001$), but the difference in cylindrical value between three groups was not significant ($p > 0.05$). According to the Intraclass Correlation Coefficient analysis, the agreement between the three methods for measuring sphere (ICC= 0.99), cylinder (ICC= 0.95), and spherical equivalent (ICC= 0.99) was good.
Conclusion: The results showed that retinoscopy and fogging subjective refraction were the most similar methods, with a small mean difference. However, the comparison between retinoscopy and subjective refraction had wider limits of agreement than retinoscopy and fogging subjective refraction. Therefore, combining different methods may lead to more accurate results in determining refractive errors in young people.

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Introduction

Cycloplegic refraction has been known as the gold standard in controlling accommodation and measuring refractive error, although it is associated with complications, including time consuming procedures, inconvenience, cost and discomfort [1]. According to the study results by Zue et al., cycloplegic refraction could be an uncomfortable method due to its invasive nature, which causes discomfort, burning sensations, blurred vision, and light sensitivity [2]. Consequently, the usage of cycloplegic drops may discourage some individuals from attending

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an eye examination. Accordingly, non-cycloplegic refraction techniques, including objective methods (retinoscopy and auto-refraction) and subjective refraction, have been extensively employed as they are easy, comfortable, and fast to perform for both the patient and practitioner. Optical fogging, as a subjective method, is broadly used for controlling accommodation by adding plus lenses in front of the examined eye. The plus lenses blur the vision and reduce accommodation to refine the best refraction [3]. It has been stated that results obtained by subjective methods are different from those obtained by retinoscopy, since the reflective layer is different between these two methods.[4] Studies comparing the effectiveness of refractometers and subjective refraction have reported that the former may result in over-minus refraction compared to subjective refraction. This is thought to be due to the stimulation of accommodation during measurement. However, recent conventional refractometers have been found to be similarly effective as subjective refraction [5, 6]. Open-field refractometers have been found to produce less myopic values than conventional refractometers and provide similar spherical refraction to subjective refraction [7]. There are few studies that specifically evaluate fogging subjective refraction and retinoscopy [8, 9] so the purpose of this study is to analyze the efficacy of three distinct approaches for measuring refractive error: retinoscopy, conventional subjective method, and subjective fogging method. The specific objectives include the extraction of the patient's refractive error utilizing each method, and the comparative analysis of the resultant refractive error and visual acuity measurements among the three methods. Furthermore, the practical aim is to ascertain the efficacy of the subjective fogging method in achieving accurate refractive error measurements.

Materials and Method

Two hundred twenty-three eyes from 223 healthy participants, aged from 18 to 35 years are examined in optometry clinic of the Mashhad University of Medical Sciences. Refractive errors measurements were conducted subsequent to providing thorough explanation of the procedures, ensuring informed consent was obtained from each participant. The inclusion criteria comprised the absence of ocular pathology, no history of surgery, no history of amblyopia, no prior refractive surgery, no medication known to affect accommodation, and no history of contact lens usage. Subjects who did not provide consent to participate in the study, exhibited contraindications for continued participation, or demonstrated low cooperation were excluded from the study at their discretion. The refractive error for the right eye of each participant was assessed utilizing the static retinoscopy method (Heine Beta 200 streak retinoscope, Heine Optotechnik GmbH, Herrsching, Germany) at a working distance of 67 centimeters. Retinoscopy was conducted while the patient fixated on a target positioned at 6 meters in a dimly illuminated room to facilitate a clearer view of the pupillary reflex. Subsequently, conventional subjective refraction (without fogging) was performed using the retinoscopy results obtained for the right eye. Queirós suggested that over-refraction with +2.00D fogging lenses induces a similar relaxation of accommodation as cycloplegia [10]. Finally, subjective refraction with fog was conducted as follows: the visual acuity of the right eye was assessed with the left eye occluded, and a +1.00 fogging lens was introduced, resulting in a decrease of visual acuity by approximately 4 lines. Subsequently, the power of the fogging lens was gradually decreased in 0.25 diopter increments until the best visual acuity was achieved. All examinations were performed by the same trained optometrist. Myopia and hyperopia were defined as a spherical equivalent refractive error of ≤ -0.50 diopters (D) and ≥ +0.5 D, respectively.

Ethical consideration

This study adhered to the principles outlined in the Declaration of Helsinki and received approval from the Ethics Committee of Mashhad University of Medical Sciences. All participants were informed about the study's objectives and procedures, and they provided written informed consent to participate.

Statistical analysis

The statistical software SPSS V11.5 was employed for data analysis. The results are expressed as mean ± standard deviation (SD) or median (interquartile range). Agreement between parameters was assessed using intra-class correlation (ICC) and Bland-Altman plots. Differences between correlated groups were evaluated using the Friedman test. The spherical and cylindrical components of refraction obtained from the three techniques were converted to mean spherical equivalent (MSE), J45, and J180 using Thibos et al.'s (1997) formulas [11] as follows:

MSE: sphere + cylinder/2

J0: - cylinder/2 * cos (2θ)

J45: - cylinder/2 * sin (2θ)

Results

A total of 223 healthy adults completed the examinations, with a mean age of 25.63±5.31 years. Table 1 presents the mean, standard deviation, median, and interquartile range of spherical, spherical equivalent, and cylinder values for the three refraction methods.

The mean spherical equivalent obtained through the subjective refraction method was more negative than that obtained through fogging subjective refraction, while retinoscopy provided the most positive results. According to the Friedman test, the difference in spherical and spherical equivalent values among the three methods was significant (p-value < 0.001), but the difference in cylindrical values between the three groups was not significant (p-value > 0.05).

Based on the Intraclass Correlation Coefficient analysis, the agreement between the three methods for measuring sphere (ICC= 0.99), cylinder (ICC= 0.95), and spherical equivalent (ICC= 0.99) was deemed good. The Bland-Altman method was utilized to compare the differences between the refraction methods and ascertain the significance of results with a confidence interval of 95% (p < 0.05). Bland-Altman plots comparing subjective refraction and fogging subjective refraction with retinoscopy are depicted in Figure 1 and Figure 2.

The mean difference between retinoscopy and subjective refraction was 0.34 (95% CI of limits of agreement: -0.22 to 0.91), slightly larger than the mean difference between retinoscopy and fogging subjective refraction, which was 0.22 (95% CI of limits of agreement: -0.28 to 0.71). The results indicated that retinoscopy and fogging subjective refraction were the most comparable, differing by only 0.22. Moreover, the 95% limits of agreement for the comparison between retinoscopy and subjective refraction were wider than those for the comparison between retinoscopy and fogging subjective refraction.

Table 1: Mean, standard deviation, median and interquartile range of spherical, spherical equivalent and cylinder for the three refraction methods

		Retinoscopy	Fogging subjective refraction	Subjective refraction
spherical equivalent	Mean ± SD	-0.16 ± 1.61	-0.38 ±1.47	-0.50±1.42
	Median	0.50	0.00	-0.13
	Interquartile range	-1.00; 0.88	-1.00; 0.50	-1.00; 0.38
Spherical refraction	Mean ± SD	0.22± 1.54	-0.01± 1.39	-0.12± 1.34
	Median	0.75	0.25	0.25
	Interquartile range	-0.50; 1.25	-0.50; 0.75	-0.50; 0.75
cylinder	Mean ± SD	-0.76± 0.62	-0.75± 0.62	-0.73± 0.63
	Median	-0.50	-0.50	-0.50
	Interquartile range	-1.00; -0.50	-1.00; -0.50	-1.00; -0.50

SD: Standard Deviation

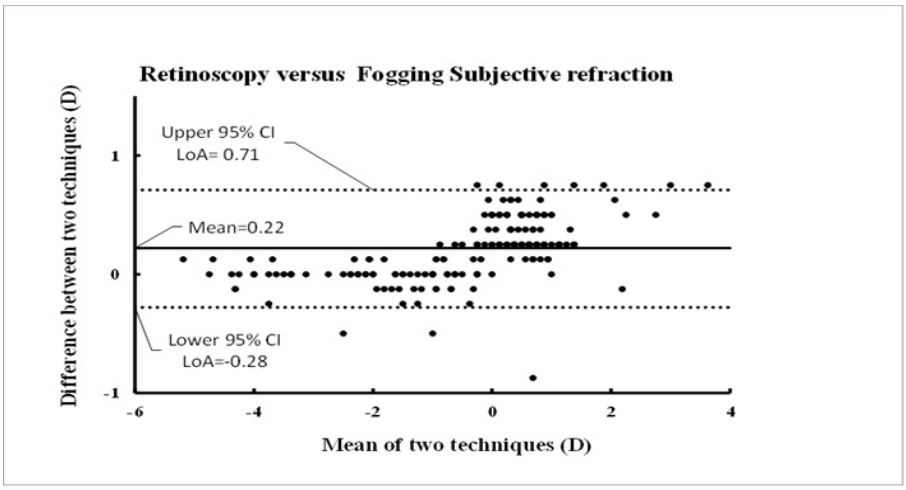

Figure 1: Bland–Altman plot between mean spherical equivalent using retinoscopy and subjective refraction. 95% limits of agreement are shown as two horizontal lines above and below the mean (-0.22 to 0.91 Diopter). Bias is shown by regression line through plot (P<0.05).

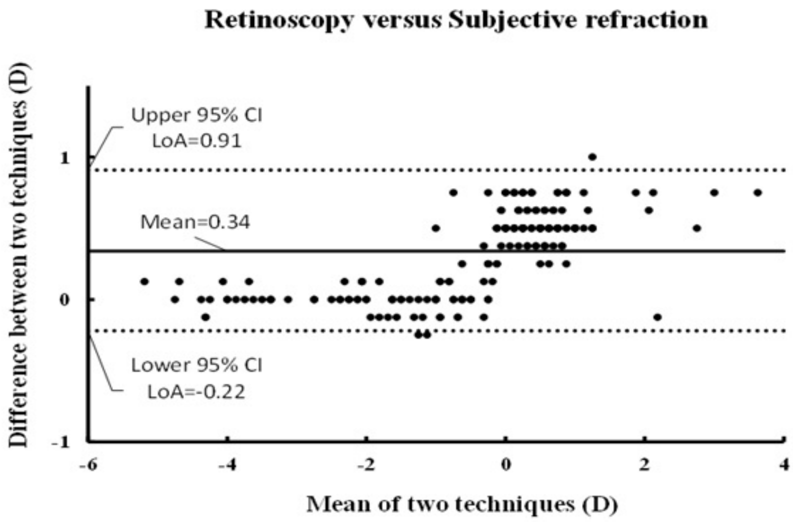

Figure 2: Bland–Altman plot between mean spherical equivalent using retinoscopy and fogging subjective refraction. 95% limits of agreement are shown as two horizontal lines above and below the mean (-0.28 to 0.71 Diopter). Bias is shown by regression line through plot (P<0.05)

Discussion

Controlling accommodation and ensuring patient compliance during ocular refraction pose significant challenges to clinicians, prompting researchers to explore various methods of refraction. Our study aimed to evaluate the level of agreement among non-cycloplegic refraction methods, including retinoscopy, conventional subjective refraction, and fogging subjective refraction, in managing accommodation in a young population.

Our findings demonstrated a notable variance in the average spherical values obtained among the three methods, with subjective refraction with fog yielding a more positive spherical value compared to conventional subjective refraction. Previous studies have also reported significant differences among various methods of refractive error measurement. However, in the study by George et al. (2005) involving 192 patients, the average difference in spherical values between retinoscopy and conventional subjective refraction was not deemed significant [12]. In a study conducted in Singapore in 2005, Farooq et al. examined 100 patients and observed a significant difference in the mean spherical values obtained from autorefraction and conventional subjective refraction [13].

In 2006, Chong et al. investigated 117 patients and identified a significant difference between the mean spherical equivalent obtained from autorefraction and subjective refraction [6]. Our study highlights a significant difference in the average spherical component of refractive error obtained among the three methods (Retinoscopy, subjective with fog, and conventional subjective method). This finding aligns with the results of Farooq et al. and Chong et al., who also reported significant differences between various methods of measuring refractive errors. Such discrepancies may be attributed to high-order aberrations in the human eye that can influence the measurement techniques employed. Contrary to our findings, the study by George et al. found no significant difference in the average sphere between retinoscopy and conventional subjective refraction. This discrepancy underscores the variability in results across different studies. Nonetheless, the collective evidence suggests that there can indeed be notable differences between different methods of measuring refractive errors. Our study contributes to this body of knowledge by specifically evaluating the agreement between three distinct methods, a comparison that had not been previously explored. Furthermore, our observation that subjective refraction with fog resulted in a more positive sphere than normal subjective refraction provides valuable insight that may aid in enhancing the accuracy of refractive error measurements in clinical practice. However, the disparity in average cylinder between retinoscopy and subjective refraction differs across various studies. Grossoner et al. observed the difference between the average cylinder obtained from retinoscopy and conventional subjective refraction to be non-significant [14]. In Milodot et al.'s study, the disparity between the average cylinder obtained from retinoscopy and normal subjective refraction was found to be significant [15].

The size of the pupil during retinoscopy could potentially lead to variances in refractive error compared to subjective refraction, particularly in cases with larger aberrations. The discrepancy may arise from the larger pupil size during retinoscopy compared to its size during subjective refraction. This difference in pupil size becomes more pronounced with increasing aberrations, resulting in greater disparities in refractive error measurements [16].

In this study, the difference in average J180 and J45 between retinoscopy and subjective refraction was found to be non-significant. Moreover, the average visual acuity obtained from subjective refraction with fog was superior to that of normal subjective refraction, which in turn was better than retinoscopy. The findings indicate that retinoscopy and fogging subjective refraction are the most comparable methods, with a mean difference of only 0.22. However, it's noteworthy that the 95% limits of agreement for the comparison between retinoscopy and subjective refraction were wider compared to those of retinoscopy and fogging subjective refraction.

The limitations of this study include the absence of cycloplegic refraction, challenges in accessing participants, and low cooperation among participants in correctly performing the tests. While this study does not undermine the importance of cycloplegic drops, it underscores the significance of paying more attention to the subjective refraction method with fogging. It is worth noting that the use of cycloplegic drops has drawbacks such as side effects, prolonged duration of effect, and lack of acceptability in some patients, particularly in children. Additionally, given the large sample size in this study and the selection of young patients, the majority of whom were under 30 years old with a mean age of 25.63, they belong to an age group with active accommodation.

Conclusion

Subjective refraction with fog emerged as the most effective method for controlling accommodation during refraction, yielding more positive spherical values compared to conventional subjective refraction. Furthermore, our findings revealed higher agreement between the two methods of retinoscopy and subjective refraction with fog, suggesting their interchangeability. The introduction of an effective method that is both practical and easily implementable by examiners is noteworthy. However, further studies in this area are warranted to enhance the accuracy and reproducibility of these findings across different age groups.

Conflict of interest

The authors declare no conflicts of interest.

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