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Comparison of Subjective Refraction Findings in Two Different Levels of Room Illumination Using Three Different Types of Letter Charts

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Purpose: The effect of two different levels of illumination and the effect of three letter chart types on subjective refraction findings were investigated. **Methods:** This study involved thirty Malay university students aged between 19 to 23 years old (7 males, 23 females), with their spherical refractive error ranged between plano to −7.75D, astigmatism ranged from plano to −1.75D, anisometropia less than 1D and with no history of ocular injury and pathology. Monocular subjective refraction was measured under two levels of illumination (with and without room light) and with three different letter charts (Snellen letter chart, wall mounted letter chart and projected letter chart). Subjective refraction finding was calculated in spherical equivalent in unit diopter (D). **Results:** There was no significant effect in the subjective refraction findings with Snellen letter chart (*t-test* = 0.15, *p-value* = 0.88), projected letter chart (*t-test* = −0.19, *p-value* = 0.85) as well as wall mounted letter chart (*t-test* = 0.12, *p-value* = 0.94). One Way ANOVA also revealed when the subjective refractive measures were compared under two different level of room illumination (with and without room light), no significant effect of letter chart types on subjective refraction readings with room light ($F_{2,185}$ = 0.11, *p-value* = 0.89) and without room light ($F_{2,185}$ = 0.02, *p-value* = 0.98). **Conclusions:** Subjective refraction findings were not affected whether the room light was on or off. They were also not affected by the types of letter chart used.

Key words: refractive error, letter charts, illumination

Introduction

There is a wide variation in the levels of illumination under which subjective refraction is carried out in optometric practices. Some practitioners carry out the subjective refraction in the examination room without room light, while others have their examination room brightly lit.

In dim illumination test room, the larger pupillary aperture brings the more peripheral parts of the crystalline and cornea into play. With a larger pupillary aperture in dim room, when light ray enters the eye, there is less diffraction effect which helps to reduce the size of airy disc. There is also a shallower depth of focus. However, when light rays pass through the peripheral cornea and crystalline lens may be focused at different plane along the visual axis due to the aspheric nature of the cornea and crystalline lens.

This enhances the effect of spherical aberration[1,2]. Consequently, a greater refractive error will be expected under dim illumination. Night myopia has been discussed and thought to be a phenomenon related to greater refractive shift in dimly lit condition. When scotopic vision takes place in very low levels of illumination, eyes become more myopic than in normal daylight. This has been cited by some practitioners to keep the examination room well illuminated. However, bear in mind, when the test room

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is kept in dim condition, the test chart is brightly illuminated. Luminance level of the test chart is remained at photopic level and fovea area on retina subjected to photopic function will remain functioning[3]. There is normal photopic function and normal colour discrimination when subjective refraction is carried out in dimly lit test room. So, it is doubtful if there is any myopic shift induced under dim condition. It is rather an optical effect which attributes to greater refractive error in dimly lit test room.

Opinion from some practitioners to perform subjective refraction in brightly lit condition has also been argued. In bright room condition, pupillary aperture reduces. Smaller pupillary aperture increases the depth of focus, which reflected a less noticeable change in vision with certain amount of variation in refractive status. This is mimicking the effect of pinhole which restricts entry of periphery light rays into the eye[1]. Therefore, only light rays that are close to visual axis enter the eye and focus at a narrower range along the visual axis, hence it reduces the spherical aberration effect and enhances the visual acuity.

Lower refractive error is obtained in brightly lit test room. However, smaller pupillary aperture may produce adverse effect as a result of greater diffraction effect. A smaller pupil aperture diffracts each light rays entering the eye to produce airy discs. These airy discs overlap with each other and reduce the visibility of test target presented during the subjective refraction procedures[2,4,5]. Patient may confuse or fail to note subtle change in fixating target during subjective refraction. An inexperience optometrist may undercorrect the refractive error in such condition, especially defining the final prescription for astigmatism correction.

An early case report from Wiseman[3] noted that performing subjective refraction in dark and bright illuminated test room produced similar prescription. However, he noticed an approximate of 0.25D change in subjective refraction when duochrome test was carried out.

According Wiseman, in darkened test room, except for the duochrome panel, the red rings appeared clearer with optimum subjective correction. Instead of adding minus lenses, when he turned on the light, the green rings became predominant. A minus 0.25D was obtained in darkened test room and an equal reversal was obtained when the light was switched on. Wiseman claimed that his finding was of little clinical significance.

Besides the effect of illumination levels on subjective refraction findings, the type of letter charts has been queried since various visual acuity charts has been used in optometric clinic set up[6-9]. With different visual acuity charts, different fixating target had been designed and catered for refining the spherical end point and astigmatism reading. Some wall mounted letter charts use cluster dot as fixating target to refine the axis and cylindrical correction while others use optotype as the fixating target. Even in the douchrome presentation, some use dark rings against green and red background while some use black optotypes progressively reduced in size against green and red background. In a study by Young et al.[10] on the standard Snellen letter chart and Vistech sine wave grating charts as refraction targets in determining differences in total time required to accomplish subjective refractions and endpoint of refractive values, they reported no clinical significant mean difference between the charts in terms of endpoint refractive data.

Different opinions regarding the levels of illumination to be used in standard visual examination room and variation in different visual acuity charts used during the subjective refraction procedures had raised the question of the variability of the refractive values obtained by different optometry practitioners.

Different guidelines for room illumination have been suggested by different ophthalmic companies, depending on the designs of the visual acuity charts. Inexperience practitioner and the optometry students who are unaware of the different set up of lighting in the examination room will obtain a subjective refraction values which might not be practically used in some other level of illumination. Thus, there is a need to investigate the clinical impact of having subjective refraction procedures carried out in dim and bright room examination and as well as the possible effect of three different visual acuity charts purchased in UiTM Optometry Department on the subjective refraction outcomes. It will serve as a guide for all optometrists.

The objectives of the second part of this study are to investigate the effect of two different levels of room illumination on subjective refractive values and also to compare the subjective refractive findings with three different letter charts.

Materials and Methods

Subject Selection

This is a crosssectional study and subjects were obtained from the first and second year of Optometry students through convenient sampling. Thirty Malays students with age ranged between 19 to 23 years old (mean: 20.71± 0.69) (7 males and 23 females) participated this study. Subject's refractive error ranged from plano to −7.75D, astigmatism ranged from plano to −1.75D, anisometropia equal to 1D or less and no history of ocular injury and pathology. All subjects had monocular visual acuity of 6/9 or better with their habitual visual correction.

Procedures

Study was carried out in three different visual examination rooms in Optometry Clinic, Universiti Teknologi MARA (UiTM) Jalan Othman. Room was equipped with Snellen letter chart (Snellen), wall mounted letter chart (WM) and projected letter chart (PC). Subjective refraction was tested at 6 meters and the chart illumination measurement with Luminometer LS100 Konica Minolta for the Snellen, WM and PC was 688lux, 435lux and 128lux respectively.

Subjective refraction was based on standard measurement protocol: first was to obtain the best vision sphere (BVS) with duochrome technique; cylindrical component with Jackson crosscylinder of +/−0.25DC was then performed using the optotype "O" one line above the visual acuity for BVS as the fixation target to refine the axis and cylindrical dioptric power; the monocular end point reading was then refined with +1.00D test and finally the binocular balancing was carried out using the successive contrast technique to obtain subjective refraction end point readings.

Each subject went through subjective refraction procedures under two different levels of room illumination, normal ambient room illumination with light on and dim room illumination with room light off using three different letter charts design (rotatable Snellen letter chart, wall mounted letter chart and projected letter chart).

Sequencing of performing the subjective refraction either in ambient room illumination or dim room illumination and the visual acuity chart types was determined by using random number chart to avoid bias which might affect the reliability of subjective refraction findings also to eliminate the psychological factor, such as tiredness as the overall procedures took an average of an hour.

In the course of this study, we involved four optometrists from Department of Optometry. Interexaminer variation was evaluated for its repeatability and reliability of the visual acuity measurement (*F-ratio* = 0.02, *p-value* = 0.99). In addition to that, to improve the reliability of the test procedures and to avoid bias of the examiners, examiners were masked from subjective refraction end points obtained by other optometrists.

Subjective refraction end point readings were then calculated in spherical equivalent form and recorded in unit diopter (D). Spherical equivalent was calculated by adding half of the cylindrical dioptric power to the spherical dioptric power {spherical equivalent = spherical dioptric power + (1/2 cylindrical dioptric power)}. The effect of the two different room illuminations on subjective refraction end point readings was tested using unpaired *t-test*[11]. The effect of three different chart types on subjective refraction was then analyzed with One Way ANOVA[11]. In this analysis, independent variable was the types of letter chart while the dependent variable was the subjective refraction. Since the variable of interest investigated in this study was the chart design, therefore, level of sig-

Table 1. The effect of two different illumination levels on subjective refraction findings were compared with unpaired *t-test* for all three types of letter charts.

Letter Charts Type	Subjective Refraction calculated in spherical equivalent, D (mean±SD)		unpaired *t-test*	*p-value*
	Room Light On	Room Light Off		
Snellen	−2.10±2.26	−2.16±2.32	0.14	0.88
WM	−2.17±2.26	−2.14±2.20	−0.08	0.94
PC	−2.29±2.27	−2.22±2.23	−0.19	0.85

*significant at level 0.05

Table 2. Subjective refraction measurements (calculated in spherical equivalent, D) obtained with three different letter charts and the refractive findings were compared with One Way ANOVA to investigate the effect of different chart types on subjective refractive findings. The effect of letter chart types on the subjective refraction findings was compared under both room conditions with and without room light

Room Light	Subjective Refractive calculated in spherical equivalent, D (mean±SD)			*F-ratio*	*p-value*
	Snellen	WM	PC		
On	−2.10±2.26	−2.17±2.26	−2.29±2.27	0.11	0.89
Off	−2.16±2.32	−2.14±2.20	−2.22±2.23	0.02	0.98

*significant at level 0.05

nificance was set at 0.05.

Results

Subjective refraction findings in ambient room illumination and dim illumination were compared using unpaired *t-test*. Level of illumination revealed no statistical significant effect on the subjective refraction findings for all three types of letter charts (Table 1).

Subjective refraction findings were also compared among the three letter charts. One way ANOVA showed that the result of subjective refraction was not significantly affected by letter chart types in both illumination condition with room light on ($F_{2.185} = 0.22$, $p\text{-}value = 0.89$) and with room light off ($F_{2.185} = 0.02$, $p\text{-}value = 0.98$). Subjective refractive findings were consistent in all tested conditions (Table 2).

Discussion

Two different levels of room illumination (with room light on and with room light off) had no statistical significant effect on subjective refraction findings. Neither were types of letter charts used as the fixation target during the subjective refractive procedures produced significant effect on subjective refraction findings.

Our findings were consistent with earlier report from Wiseman[3].

Performing subjective refraction in both illumination levels with room light on and with room light off produced different in subjective refraction findings regardless of the types of letter charts used in the procedures. When the subjective refraction was performed with room light on, it was the photopic function of the fovea area that was tested. Similarly, when the room light was off, bright luminance from the visual acuity chart (internal illuminated and projected chart) was indeed stimulating the photopic function of the fovea area, which required the cone photoreceptor to distinguish relative difference or subtle change in fixated target on the high luminance visual acuity chart[3]. Furthermore, the level of luminance of the letter charts used in our study gave a luminous range from 128lux to 688lux.

The level of minimum chart luminance was remained way higher than luminance level of pure scotopic vision, 0.034 cd/m^2. Photopic function took over the function of human eye when the luminance level was equal or greater than 3.4 cd/m^2. Hence, the level of chart luminance used in the optometric clinical set up was indeed measuring the photopic function of visual system[12].

There was no significant difference in subjective refraction findings when the procedure was carried out with three different letter charts for both two different levels of room illumination. The Snellen letter chart and wall mounted letter chart were both internal illuminated to give maximum contrast for the optotype displayed on the charts. However, it was interesting to observe unchanged subjective refraction findings with projected letter chart.

This observation probably showed there was a loss in contrast level of the optotype presented on projected letter chart when the room light was on, but the optotype discrimination from its background followed the Weber's Law. Weber's Law implied that as the background brightness increased, the increment intensity must be increased such that the ratio of the increment intensity to the background intensity remained constant[12]. Optotype presented in dark without room light did not become more visible than when the optotype was presented in room with light on.

A consequence of this characteristic was that the appearance of the optotype remained unchanged as the lighting conditions varied, which it was referred as light constancy. Detection of the optotypes presented on the projected letter chart was unchanged between the room conditions with and without room light. Hence, using same optotypes as the fixation target to refine the end point of subjective refraction and the cylindrical correction was not affected in different room illumination.

In carrying out this part of study, we have set up a test protocol and examiners were strictly followed the protocol to accomplish the subjective refraction procedures. Our data suggested that when the subjective refraction procedures were carried in accordance to test protocol, a more reliable and repeatable subjective refraction findings could be attained even though different letter charts and room illumination were used in clinical set up. Therefore, it is essential in future clinical room set up, optometrist must practice careful and consistent test procedures in order to minimize the deviation of the subjective refraction findings.

Conclusion

There was no significant effect of the two different levels of room illumination on the subjective refraction findings for all three types of letter charts used in the optometric procedures in UiTM Optometry Clinic.

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