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Optometric Education The Journal of the Association of Schools and Colleges of Optometry

Abstract

Purpose: *To determine whether room illumination affects refractive results and to determine how room illumination for refraction is being taught at schools and colleges of optometry.* ***Methods:*** *Subjects were refracted in two rooms, brightly illuminated and moderately illuminated, using a computerized visual acuity chart. Subjects were surveyed about lighting preference. Teaching institutions were surveyed on room illumination and the visual acuity chart used during refraction.* ***Results:*** *No significant difference between refractions was noted. Schools using computerized charts teach students to use moderate or bright room illumination.* ***Conclusion:*** *Room illumination no longer plays a critical role in refraction due to use of computerized visual acuity testing systems. This should impact how refraction is taught in the optometric curriculum.*

Key Words: *manifest refraction, subjective refraction, visual acuity, illumination*

Background

Visual acuity (VA) is the most frequently assessed visual function in the clinical setting. Optimal refractive correction and the subsequent VA is essential for quantifying sensory function, detecting and monitoring ocular disease affecting central vision, and conducting clinical research. However, research on lighting conditions and how they affect VA and refractive error has rarely been performed and has produced conflicting results. A study by Wozniak et al. examined the effect of room illumination on VA measurements. Results showed that VA was reduced in non-emmetropic subjects when refraction was performed in non-illuminated rooms compared to when it was performed in illuminated rooms using a retro-illuminated Snellen chart.[1] In contrast, Chen et al. compared results of VA testing with room light and without room light using three different VA charts and found no difference in VA due to room illumination. The three different types of charts used were a projector letter chart, a wall-mounted letter chart and an internally illuminated rotatable Snellen chart.[2] An early clinical finding by Wiseman in 1956 was that subjective refraction in dark and bright room illuminations produced similar prescriptions using projector VA charts.[3] Another study by Chen et al. compared subjective refraction results in two different room illuminations using the same three VA charts. This second study found no statistically significant difference in subjective refraction with and without room illumination.[4] Many parameters of measuring VA have been standardized, including chart distance, optotypes, chart luminance, instructions on testing procedures, and scoring the VA result, but little attention has been paid to room illumination and its effect on refractive results.[5,6]

A search of the current literature on how to refract reveals a lack of updated research and recommendations on the best lighting conditions to use with computerized VA charts. Many textbooks are devoted to the topic of the subjective manifest refraction. However, one key element to this process appears to be missing or outdated. Standardization of the lighting conditions in the examination room during the subjective refraction has not been addressed for computerized VA charts. Commonly used textbooks for teaching optometric students how to test VA and perform subjective manifest refraction have variable recommendations for room illumination. Some only address room illumination as it relates to projector VA charts.[7,8] Others recommend the room be dimly illuminated for projector charts and computerized charts alike.[9, 10] Another text has specific recommendations on chart luminance ranges with only a generalized recommendation that room lighting be moderate unless the correction will be used primarily in dim or dark surroundings.[11]

Observation of students' clinical exams at ICO revealed that various levels of room lighting were being used during manifest refraction and binocular balance. Illumination ranged from full brightness to total darkness. The amount of variation was surprising because the students are taught to use moderate room illumination in their first year at ICO. The wide variation led the authors to survey ICO faculty and alumni about their own lighting preferences. The survey indicated that lighting preferences for manifest refraction vary in both academic and clinical optometric communities. The majority of ICO faculty 79% (30/38) and alumni 73% (190/260) reported using dimmed medium illumination during refraction. The majority of ICO faculty who refract in dim illumination reported that they were concerned that too much room illumination reduced contrast on the chart. The majority of alumni who refract in dim conditions reported it was their preference not to work in a totally dark room and that a dim room most closely simulated real-life conditions. Both ICO faculty and alumni who reported a preference for refracting in bright illumination stated that this lighting simulated real-life conditions.[12]

Due to the current lack of information in the literature on standardization of lighting conditions for computerized VA charts, this study was undertaken to determine whether room illumination affects the final refractive outcome after subjective refraction and binocular balance and whether patients have a preference for either setting. Also, due to the wide variation in light conditions used by ICO faculty and alumni for subjective refraction, a survey of the members of the Association of Schools and Colleges of Optometry Special Interest Group (Clinical Optometric Methods & Procedures

Instructors) was conducted. The survey was used to determine the illumination conditions for refraction currently being taught at different optometric institutions, reference material used to teach refraction, prevalence of computerized VA charts, and whether their use has affected how clinical faculty members instruct optometry students on room illumination.

Methods

Seventy-one subjects were recruited from the staff, student body and faculty of ICO. Each subject had undergone a comprehensive eye exam in the last 24 months. Any subject who presented with amblyopia or ocular disease, except for mild dry eye syndrome, was excluded. The age of subjects ranged from 23 to 59 years with a mean age of 27 years. All subjects were correctable to 20/30 or better. Informed consent was obtained from all subjects before participation in the study. The protocol was approved by the Institutional Review Board of the Illinois Eye Institute.

The subjects were refracted by two different doctors in adjoining, identical (except for illumination level) exam rooms on the same day. Each examiner performed the subjective refraction followed by binocular balance on each subject in the same manner. The examiners were masked from the refractive results of the other examiner to avoid bias. Subjects were randomly assigned to start in either room to avoid bias or tiredness that might affect the reliability of the results. The entire procedure took 30 minutes. Nidek Tonoref II autorefraction measurements were used as the starting point for both refractions. Subjective manifest refraction including binocular balance was performed in both rooms with an M&S Technologies Smart System 2020 computerized VA chart with an LCD monitor. The letters on the chart were randomized to prevent memorization.

Examiners were randomized to either a brightly illuminated examination room or a moderately illuminated examination room for each patient. One exam room was brightly illuminated using overhead room lights to 320 lux while the other room was moderately lit to 3.5 lux by using a 60-watt bulb stand lamp positioned behind the patient’s head with the overhead room lights off. A Sekonic L-758Cine DigitalMaster light meter was used to control the amount of light in each room. Each subject’s pupil size was measured prior to the refraction in each of the exam rooms using an infrared Colvard pupillometer after he or she adjusted to the room’s illumination for approximately 30 seconds. The subjects viewed the computerized VA chart while the pupil sizes were measured.

After the testing, subjects were asked to complete a three-question survey inquiring whether they were more comfortable in a particular lighting condition, why, and under which lighting condition they felt their vision was clearest **(Appendix A)**.

A paired T-test was performed to compare the spherical equivalent refraction and the spherical and cylindrical components of the final binocular balance result of the right and left eyes in the bright illumination and the moderate illumination. The pupil sizes of right and left eyes in the bright illumination and the moderate illumination were also analyzed with a paired T-test.

A second survey **(Appendix B)** was created for the members of the Clinical Optometric Methods & Procedures Instructors Special Interest Group of the Association of Schools and Colleges of Optometry (ASCO). This group consists of faculty members from the 23 ASCO member schools and colleges who instruct students on how to perform subjective manifest refraction. The survey consisted of six questions and was administered using Survey Monkey software. The purpose was to determine the illumination conditions for refraction currently being taught at optometric institutions, what reference materials are used to teach refraction, and the prevalence of computerized VA charts and whether their use has affected how clinical faculty members instruct optometry students on room illumination for subjective refraction.

Results

A total of 142 eyes of 71 patients were tested. The spherical equivalent of the subjects’ refractive error for OD and OS ranged from +1.25D to -13.25D. Average spherical refraction was -3.04D in bright illumination and -3.06D in moderate illumination, OD, and -2.99D in bright illumination and -2.98D in moderate illumination, OS. A spherical equivalent change of +/- 0.50D was considered a clinically significant refractive difference. Paired T-tests to compare the spherical equivalent binocular balance revealed no significant difference between the two illumination conditions for either eye (OD: p=.40 and OS: p=.92) **(Figure 1)**. Paired T-tests to compare the spherical and cylindrical components of the binocular balance between the two illumination levels also revealed no significant difference for either eye (OD sphere: p=.26, OS sphere: p=.36, OS cylinder: p=.58, OS cylinder: p=.72) **(Figure 2)**. As expected, pupil size in the two illumination conditions was significantly different (p<0.001). The mean pupil size in the brightly illuminated room was 5.1 mm and the mean pupil size in the moderately illuminated room was 6.7 mm.

ASSOCIATION of SCHOOLS and COLLEGES of OPTOMETRY

Optometric Education The Journal of the Association of Schools and Colleges of Optometry

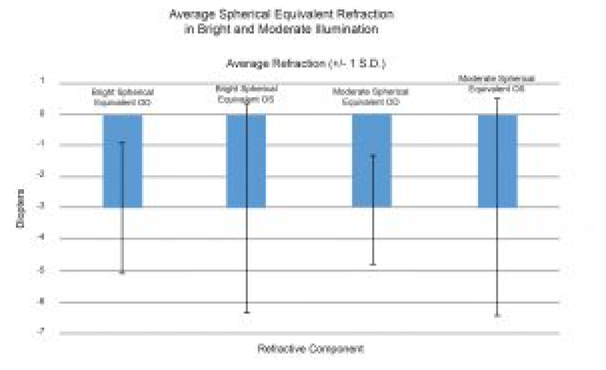

Figure 1. Click to enlarge

Subjects were asked to comment on which of the lighting conditions they found to be most comfortable and which lighting condition provided them the clearest vision. The post-refraction survey revealed no single patient preference for light level when evaluated for comfort. The patient preference was divided with 29% preferring bright, 36% preferring moderate, and 36% reporting no preference. Subjects' responses also differed regarding the lighting condition that provided the clearest vision with 29% stating bright illumination, 39% stating moderate illumination, and 33% stating that the lighting conditions did not affect their clarity of vision.

Seventy percent (16/23) of the surveyed members of the ASCO Special Interest Group responded to the survey. One respondent completed five of the six questions. The majority (11/16, 69%) reported that their optometric teaching institutions use computerized VA charts in their clinical teaching laboratories, and 31% (5/16) reported that their institutions use projector charts.

Of the schools using computerized VA charts, 50% (5/10) said they instruct their students to use moderate room illumination. The other half (5/10) said they teach their students to use bright illumination. Responses indicated that no institution teaches students to refract in a dark room or that it is acceptable to refract in any room illumination. Among the schools and colleges currently using computerized VA charts, 36.4% (4/11) reported changing the illumination levels they teach students for refraction when they switched from projectors to computerized VA charts, and 36.4% (4/11) reported no change in instruction. The remaining 27.2% (3/11) of schools with computerized VA charts reported never having taught students with projector charts. One of those three optometric schools is newly established.

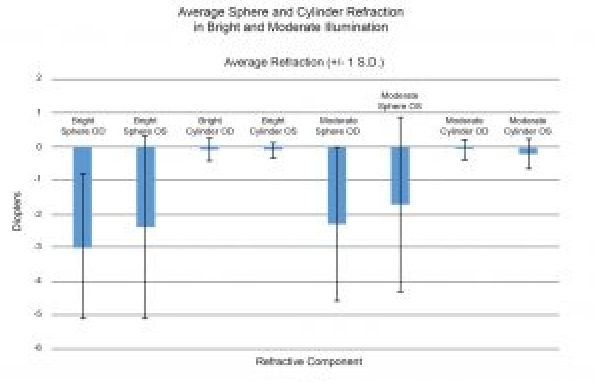

Figure 2. Click to enlarge

The survey also found that every institution currently using projector VA charts (5/16) instructs its students to use moderate room illumination for refraction. The majority of respondents (63%, 10/16) said that 15 years ago, when projector VA charts were most likely the standard, their school taught students to use moderate room illumination. In addition, the survey found that six reference books are being used to teach refraction at 14 of the 16 respondents' schools. The most commonly used books are "Clinical Procedures for Ocular Examination" by Nancy Carlson and Daniel Kurtz (69%, 11/16) and "Primary Care Optometry" by Theodore P. Grosvenor (50%, 8/16). Two of the optometric institutions created their own material in the form of a textbook or iBook with no outside reference material recommended to students.

Discussion

Research on appropriate lighting and how it affects refractive error has rarely been performed. There is a trend toward increased use of computerized VA charts, and the current literature lacks updated recommendations on the best lighting conditions to be used with these charts. Our survey to the ASCO Special Interest Group (Clinical Optometric Methods & Procedures Instructors) revealed that when institutions switched from projector to computerized VA charts, half (4/8) did not change their instructions on room illumination for refraction. The other half (4/8), who did update their instructions, changed the room illumination from moderate to bright. According to the survey results, no optometric school or college that uses computerized VA charts teaches students that either moderate or bright room illumination is acceptable for refraction. This is significant because this study revealed no clinically significant difference in the outcomes of subjective refraction and no patient preference for either moderate or bright room illumination.

This study had several limitations. One limitation was the subjects were all correctable to 20/30 or better and without significant ocular disease. The majority of subjects were also optometry students who were familiar with refraction. This familiarity with the procedure may have influenced the lighting preference reported on the post-refraction survey. The survey's mixed results on lighting preference may be explained by the subjects' biases prior to the study. Another limitation of the study was the use of a single computerized VA chart with a standardized LCD screen. The M&S Technologies Smart System 2020 monitor is calibrated to the luminance recommended by the International Organization for Standardization's "visual acuity testing – standard and clinical optotypes and their presentation" standard. This standard allows for luminance to range from 80-320 cd/m2.[13] Due to the range of recommended luminance, other computerized VA charts may not be equivalent.

Anecdotal clinical experience and past practices reported by those who refract with a projector chart appear to reinforce the recommendation to use moderate illumination when refracting with a projector chart. By controlling room illumination, glare and reflection are minimized, which optimizes image contrast. Glare from overhead lighting degrades the contrast of the image from a projector chart. Light falling on the chart from the room illumination can reflect into the patient's eye and degrade the contrast of the image on the chart, but it is not practical to refract in a dark room.[14,15] That is why it is important to develop standardized room illumination levels.

Another problem that can arise with projected VA charts is that projectors tend to decrease in illumination over time due to the incandescent bulbs they use. Incandescent bulbs lose light output as dust collects on the bulb and as the bulb ages due to the thinning of the filament.[16] The image can then become blurred due to defocus of the projector. The projected image can also be negatively impacted due to dust collected on the lens or a misalignment with the screen or mirrors.[17]

Computerized VA charts have many advantages over projector charts. They provide better contrast and more diversity compared with projected charts. Computerized VA charts meet the ISO standards for luminance, contrast and color temperature. Computerized VA charts allow the examiner to randomize optoypes to prevent patient memorization of the chart. The computerized systems offer a variety of VA charts such as Snellen, Lea, ETDRS and Tumbling E. The examiner has the ability to alternate quickly between the different types of charts. The examiner can isolate a letter or line that appears in the middle of the screen. Videos and pictures that aid with patient education can also be added. Due to the reduced cost of computerized VA charts and the many advantages they have over projector charts, the sales and utility of projector charts have been on the decline.

Many projector charts remain in use, but there has been an increasing trend toward computerized VA systems. During the 1990s and early 2000s automatic projectors made up about half of projector sales. In 2006, the first Windows-based computerized VA charts came on the market. In the mid-2000s the cost of automatic projectors was similar to the cost of computerized VA charts, and by the end of the decade more computerized VA systems were being sold than manual projector VA charts. Currently, computerized VA systems dominate the market with 75%-95% of sales.[18,19]

Our survey revealed that the majority of optometry students, 70%, have been instructed throughout their lab courses and clinical exam experience to use moderate room illumination for subjective manifest refraction. This originates from the previously standard utilization of projector charts. However, in today's practice, computerized VA charts dominate examination rooms and clinical teaching labs at the majority of optometric institutions, yet no teaching institution using computerized charts has made a change to instructional standards based on our research. Our findings are consistent with an earlier study by Chen et al. that room illumination does not have a statistically significantly effect on subjective refraction.[4] Our study is unique because it evaluates refraction with computerized VA charts, the new standard, instead of wall-mounted charts, internally illuminated charts, or projector charts. The findings of this study — that there is no significant difference in the outcome of subjective refraction and no patient preference for any room illumination — should impact how the procedure is taught in optometric curricula and how it is performed in clinical practice.

Conclusion

Obtaining an accurate subjective refraction for patients is an essential component of quality care in clinical optometric practice. In the past, it was commonly believed that room illumination played an important role in obtaining an accurate refraction with projector VA charts. With the use of computerized VA charts, room illumination no longer plays a critical role. This study determined that the final refractive outcome of the binocular balance does not significantly differ whether it is obtained in bright or moderate room illumination when utilizing a computerized VA chart. These findings should impact how the procedure is taught in optometric curricula and how it is performed in daily clinical practice.

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ASSOCIATION of SCHOOLS and COLLEGES of OPTOMETRY

Optometric Education *The Journal of the Association of Schools and Colleges of Optometry*

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Appendix A

Survey for Study Subjects After Both Refractions

1. Under which lighting condition were you most comfortable:
   a. Dim
   b. Bright
   c. No difference
2. If you were more comfortable under a particular lighting condition, please select all reasons that apply:
   a. I just liked when there was more light in the room
   b. I just liked when there was less light in the room
   c. I thought there was less glare on the chart
   d. I thought there was more glare on the chart
   e. I thought there was better contrast on the chart
   f. I thought there was less contrast on the chart
3. Under which lighting condition did you feel your vision was the most clear:
   a. Dim
   b. Bright
   c. No difference

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