APPENDIX: EE

A fully automated remote refraction system

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Summary

Traditional methods of performing refractions depend on a trained refractionist being present with the subject and conducting an interactive form of subjective testing. A fully automated refraction system was installed in 13 optical dispensaries and after 15 months the patient and statistical information was gathered. The data from all operators were consistent and suggested a lack of operator effect on the refraction results. The mean of the SD of subjective sphere measurements was 0.2, or slightly less than a quarter dioptre, which would be an acceptable level of accuracy for ordering corrective lenses. The present study suggests an absence of operator influence on the results of the refractions and a degree of consistency and accuracy compatible with the prescription of lenses.

Introduction

Most ophthalmic instruments can produce results in a form which can be transmitted to an ophthalmologist and lend themselves well to telemedicine. Subjective refractions have remained resistant to this type of development because traditional methods of performing refractions depend on skilled refractionists employing an interactive procedure with the subject. This interaction can be influenced by many factors. There is no satisfactory way to record these factors, their origins or their effects on the final result, nor is there a reproducible way to assess or record the overall accuracy of the refraction, apart from the general impression of the refractionist. The number of tests and duration of testing are determined by the ability of the refractionist to minimize the number of iterative steps necessary to determine the three basic elements of a subject's refractive error: sphere, cylinder and axis. Because any one element cannot be accurately tested while either or both of the other two are uncorrected, the testing process is of necessity iterative.

The present study was performed using a fully automated refraction system. The objectives were to determine whether there was any evidence of an operator effect on the results and whether the information produced would be sufficient for the remote prescription of corrective lenses.

Methods

Software was developed with the following objectives:

(1) to create a single software testing program applicable to all subjects;
(2) to reduce the operator's responsibilities to asking prompted questions of the subject and recording the subject's responses using single keystroke entries—no refractionist skills would therefore be required;
(3) to remove the iterative nature of subjective testing by creating a single test to calculate cylinder and axis simultaneously and thus reduce the elements to be tested to two;
(4) to record accurately all of the subject's responses and assess the accuracy of those responses by statistical and mathematical methods and record the results;
(5) to make it possible for the refractionist to determine the accuracy of the refraction and the subject's refractive error by reviewing the results of the test but without involvement in the process.

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The statistical methods used by the program were:

(1) regression analysis between objective and subjective results to determine the following—correlation coefficients (OSCCs) for groups of 100 eyes each tested for sphere, cylinder and axis; a regression equation to apply to subsequent objective measurements to eliminate any consistent errors; confidence limits from this regression to evaluate the accuracy of subsequent subjective refractions;
(2) calculated means and SDs for all tests which determine spherical equivalent power.

Mathematical functions performed by the program were:

(1) the calculation of spherical equivalent by fogging with plus lenses to make the subject myopic and calculating the degree of myopia from measured fogged visual acuity[1];
(2) the calculation of cylinder and axis from modified lens addition formulae[2] using the angles of a two-line astigmatic fan image viewed on a monitor through a testing cylindrical lens;
(3) applying to the calculated cylinder power a previously

Table 1 Correlation coefficients between objective and final spherical equivalents for 100 eyes among 13 operators

Operator	Highest correlation coefficient (best 100 eyes)	Rank	Correlation coefficient for the last 100 eyes tested	Rank	Total number of eyes tested	Total rank
1	0.9944	6	0.9936	8	567	14
2	0.9934	10	0.9854	21	703	31
3	0.9935	9	0.9784	24	1932	33
4	0.9926	12	0.9752	26	1426	38
5	0.9965	1	0.9947	4	1892	5
6	0.9888	15	0.9826	23	246	38
7	0.9904	14	0.9753	25	1722	39
8	0.9945	5	0.9841	22	1351	27
9	0.9952	3	0.9887	16	1502	19
10	0.9927	11	0.9886	18	989	29
11	0.9955	2	0.9887	17	721	19
12	0.9884	19	0.9860	20	1778	39
13	0.9936	7	0.9914	13	1225	20
Mean	*0.9931*		*0.9815*			*27*
SD	*0.002*		*0.006*			*11*

Correlation coefficient between total number of eyes tested and OSCCs for the best 100 eyes = 0.08 and for the last 100 eyes group = −0.23 and for total rank = 0.02.

calculated regression formula to find the minimum effective cylinder power;

(4) 'calculating' vision equalization as a substitute for the subjective testing of vision equalization[3] by obtaining the differences in spherical equivalents between right and left eyes for each test.

The refracting equipment and software were installed in 13 optical dispensaries in Alberta between January 1997 and April 1998. The patient data and statistical information were collected from all 13 computers.

The statistical information selected for study was:

(1) the type of regression analysis which produced the highest OSCC for spherical equivalent values;
(2) all these OSCC values;
(3) the mean and SD of the OSCC values for the 13 operators;
(4) OSCC values for the last 100 eyes tested by each of the 13 operators;
(5) a ranked test of the means of the best OSCCs for a group of 100 eyes and the OSCCs of the last 100 eyes tested;
(6) the mean and SD of the spherical equivalent power for each eye was obtained from the results of the regression-corrected objective refraction; from both red and green end-points obtained subjectively in the red–green test; from the highest and lowest dioptre power preferred subjectively by the subject.

For each operator the mean of the SDs of spherical equivalent power obtained for all the eyes tested was calculated. Finally, the SD among the 13 operators of the above means of the SDs of spherical equivalent powers was calculated.

Table 2 Means of SDs of spherical equivalent measurements

Operator	Means of SDs of spherical equivalent measurements (dioptres)	Number of eyes
1	0.1978	567
2	0.2018	703
3	0.1747	1932
4	0.2051	1426
5	0.2286	1892
6	0.1779	246
8	0.2316	1351
9	0.1940	1502
10	0.2291	989
11	0.1758	721
12	0.2445	1778
13	0.1038	1225
Mean	*0.1989*	
SD	*0.035*	

Results

For 12 operators the highest OSCC was obtained by power regression analysis (i.e. log x and log y) and for one by logarithmic regression analysis (i.e. x and log y). Table 1 gives the highest OSCCs obtained and the OSCCs for the last 100 eyes tested by each operator. Table 2 gives the mean of the SDs of spherical equivalent measurements of all eyes tested.

Discussion

In the present study high OSCCs were to be expected since the same entity (spherical equivalent of refractive error) was

ompared. Because one entity was measured objectively and ıe other subjectively, any operator effect on the results would affect only the subjective element. Consistency of OSCC values among the 13 operators would then suggest a lack of operator effect on the results.

The first consideration is whether the OSCC values are consistent among the different operators for the 100 eyes which produce the highest OSCCs (the 'best 100 eyes') and the 100 eyes last tested (the 'last 100 eyes'). The SD among the 13 operators of the OSCCs for the best 100 eyes was 0.002 and for the last 100 eyes was 0.006 (Table 1). The OSCC values of the best and last 100 eyes for all operators were ranked and the sum of the two ranks for each operator obtained. Table 1 shows the rankings of the OSCC values and the total ranking for each operator. Two results skewed the distribution to the higher OSCC side.

The second consideration is whether there is any correlation between the number of eyes tested and the OSCCs of the best 100 eyes, the last 100 eyes and the total rank for each operator. The correlation coefficient between total number of eyes tested and OSCCs for the best 100 eyes group was 0.08 and for the last 100 eyes group was −0.23 and for total rank was 0.02 (Table 1), indicating no correlation in either group. These figures suggest a lack of operator effect on the refraction results.

The other question is whether a refractionist can receive sufficient information to assess a subject's responses to the point that corrective lenses can be ordered. The mean of the SD of subjective sphere measurements (Table 2) was 0.2 or slightly less than a quarter dioptre, which would be an acceptable level of accuracy for ordering corrective lenses.

The present study suggests an absence of operator influence on the results of the refractions and a degree of consistency and accuracy compatible with the prescription of corrective lenses.

References

1 Duke-Elder S. *System of Ophthalmology*. London: Henry Kimpton, 1970: vol. V, p. 270
2 Ibid.: 673–4
3 Podos MS, Yanoff M. *Textbook of Ophthalmology*. New York: Gower Medical, 1991: vol. 1, p. 9.26

The potential of a nursing education support system using videoconferencing

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Summary

Japan currently employs a total of 400,000 practical nurses, accounting for approximately 40% of the total number of nurses in the country. An education system for improving the skills of practical nurses and encouraging them to obtain certification as registered nurses is due to begin in 2001. In Hokkaido, 90 nursing schools are scheduled to be used as transitional education facilities. These, however, tend to be concentrated in large cities. We have examined the possibilities for an education support system for nurses using videoconferencing. The system will include theoretical lectures using television broadcasts and technical lectures conducted at training facilities. Given Hokkaido's geographical conditions, a support system using telecommunication is considered to be essential for the success of transitional education.

Introduction

In Japan, practical nurses with 10 years' experience or more are eligible for a transitional education programme, due to start in 2001, which has been established to enable them to become registered nurses. The curriculum consists of theoretical and technical lectures. The theoretical lecture courses are planned to be given by the University of the Air, while technical lectures will be conducted at transitional education facilities, for which existing nursing schools will be used. Students are required to take 31 credits (930 lesson hours). Students completing transitional education are entitled to take the same national examination as students completing other training courses.

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Hokkaido

Hokkaido, the northernmost island of Japan, is characterized by a severe winter climate and a low population density.