Comparisons of spherical equivalent refraction findings determined by the Focometer, the PolyU Optometer, and the Topcon ARK-2000 Auto-refraction system.

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Purpose

The Focometer (Fig. 1) is a monocular device to measure subjective spherical refraction. The PolyU Optometer (Fig. 2), on the other hand, is a spectacle mounted binocular Galiliean telescope calibrated to measure subjective spherical refraction as well. The purpose of this study is to compare subjective refraction findings using these two devices. In addition, subjective refraction findings with the PolyU Optometer are compared with the objective spherical equivalent refraction findings determined by an Auto-refraction system (Topcon ARK-2000).

Figure 1. Focometer

Figure 2. PolyU Optometer

Methods

Experiment 1: Spherical refraction findings with the use of the Focometer and the PolyU Optometer were obtained from 28 subjects. Test distances of each subject for the Focometer and the PolyU Optometer were 5 and 3 meters respectively. These subjective refraction findings were then analyzed using Bland-Altman plot, paired t-test and regression analysis.

Experiment 2: The same subjects also underwent objective refraction with the use of the Topcon ARK-2000 Auto-refraction system. The PolyU Optometer's subjective spherical refraction data were then compared with the objective spherical equivalent refraction data obtained with the Auto-refraction instrument using the same statistical analyses.

Results

Subjective and objective refraction findings were analyzed using Bland-Altman plot, paired t-test and regression analysis as follows.

1. PolyU Optometer vs. Focometer

Before the direct comparison by paired t-test, differences between the Focometer and the PolyU Optometer were regressed on the averages of the two values. As the slope estimate was -0.0105 in OD which is not significantly different from zero at 0.05 level, the difference does not depend on the magnitude of the measurement. But slope estimate was 0.2206 in OS, which was significantly different from zero. The value of R^2 was 0.273 which indicate that 27.3% of variation in difference is accounted for by the averages, which are used as a measure of the magnitude. Because correlation is small, and the slope estimate is also small, although statistically significantly different from zero, it does not seem inappropriate to compare the polyU Optometer reading to the Focometer measurement directly, using paired t-test. The mean difference (PolyU Optometer results minus Focometer) is -0.12D in OD and -0.11D in OS. Neither was significantly different from zero, according to the paired t-test P=0.4588 in OD and P=0.5515 in OS. The 95% limits of agreement for the difference were ±1.57D in OD and ±1.85D in OS, meaning that on average there is 95% confidence that the difference was between -1.69D and 1.46D in OD as shown in Fig. 3, and between -1.96D and 1.74D in OS as shown in Fig. 4.

Focometer readings were regressed on the PolyU refractions. As shown in Fig. 5 and Fig. 6, the estimates of intercept were 0.0283D in OD and -0.3135D in OS, which were not significantly different from zero at 0.05 level, indicating no systematic disagreement. The value of R^2 is 0.8936 in OD and 0.8757 in OS.

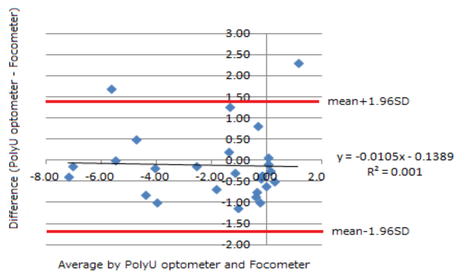

Figure 3. Bland-Altman plot between PolyU opometer and Focometer (OD)

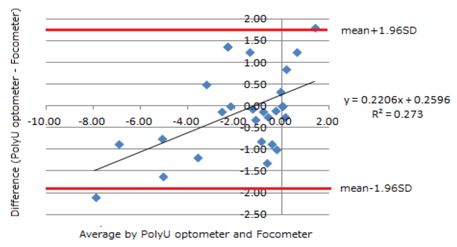

Figure 4. Bland-Altman plot between PolyU Optometer and Focometer (OS)

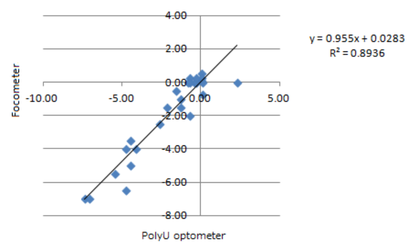

Figure 5. Regression of Focometer on PolyU Optometer (OD)

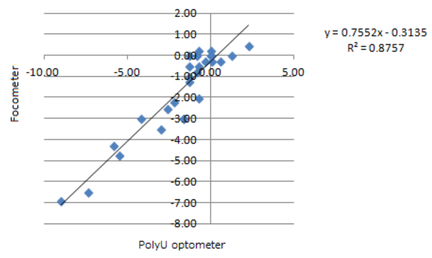

Figure 6. Regression of Focometer on PolyU Optometer (OS)

2. PolyU Optometer vs. Auto-refraction system

Differences between the PolyU Optometer readings and the Auto-refraction system were regressed on the averages of the two values. As the slope estimate was 0.0287 in OD and 0.1709 in OS which were not significantly different from zero at 0.05 level, the difference does not depend on the magnitude of the measurement. The mean difference (PolyU Optometer results minus auto-refraction system) is 0.34D in OD and 0.39D in OS. Neither was significantly different from zero, according to the paired t-test P=0.1596 in OD and P=0.1086 in OS. The 95% limits of agreement for the difference were ±2.24D in OD and ±2.58D in OS, meaning that on average there is 95% confidence that the difference was between -1.90D and 2.59D in OD (Fig. 7) and between -2.19D and 2.96D in OS (Fig. 8).

As shown in Fig. 9 and Fig. 10 the PolyU Optometer readings were regressed on the Autorefractor. The estimates of intercept were -0.5985D, P=0.0457 in OD and -0.9191D, P=0.0025 in OS, which were significantly different from zero, indicating instrument-induced myopia in Auto-refraction system. The values of R^2 were 0.8211 in OD and 0.7835 in OS.

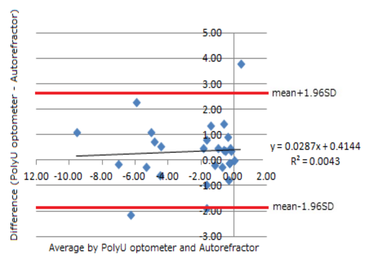

Figure 7. Bland-Altman plot between the PolyU opometer and Autorefractor (OD)

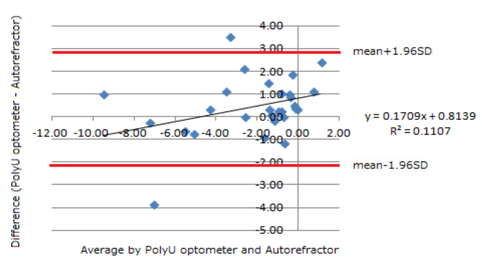

Figure 8. Bland-Altman plot between PolyU opometer and Autorefactor (OS)

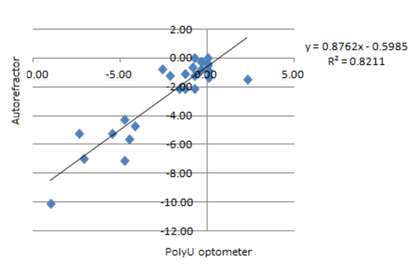

Figure 9. Regression of Autorefractor on PolyU Optometer (OD)

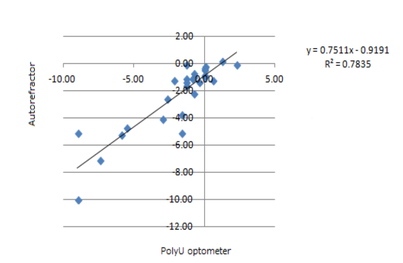

Figure 10. Regression of Autorefractor on PolyU Optometer (OS)

3. Focometer vs. Auto-refraction system

Differences between the Focometer findings and the Auto-refraction system were regressed on the averages of the two values. As the slope estimates were 0.0894 in OD and 0.0444 in OS which were not significantly different from zero, the difference does not depend on the magnitude of the measurement. The mean differences (Focometer minus Autorefractor) were 0.43D in OD and 0.47D in OS. Both of them were significantly different from zero, according to the paired t-test P=0.0098 in OD and P=0.0013 in OS. The 95% limits of agreement for the difference were ±1.56D in OD and ±1.48D in OS, meaning that on average there is 95% confidence that the difference were between -1.12D and 1.99D in OD (Fig. 11) and between -1.01D and 1.96D in OS (Fig. 12).

As shown in Fig. 13 and Fig. 14 the Autorefractor readings were regressed on the Focometer readings. The estimates of intercept were -0.6851D, P=0.0010 in OD and -0.6926D, P=0.0007 in OS, which were significantly different from zero, indicating instrument-induced myopia in Auto-refraction system. The values of R^2 were 0.8948 in OD and 0.8741 in OS.

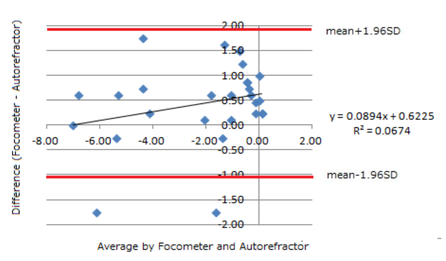

Figure 11. Bland-Altman plot between the Focometer and Autorefractor (OD)

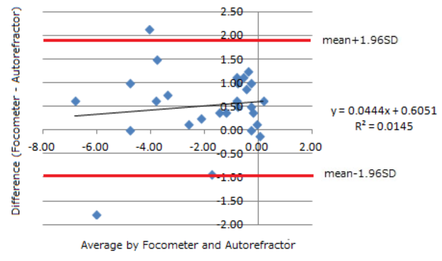

Figure 12. Bland-Altman plot between Focometer and Autorefactor (OS)

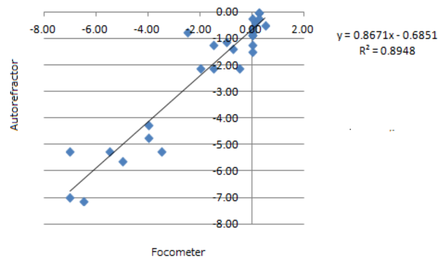

Figure 13. Regression of Autorefractor on Focometer (OD)

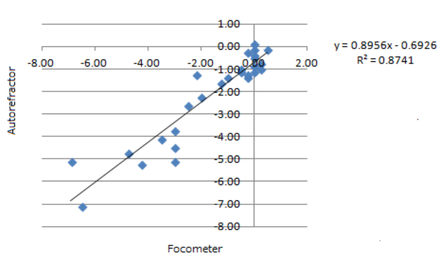

Figure 14. Regression of Autorefractor on Focometer (OS)

Discussion

Spherical equivalent refraction findings obtained with the use of the PolyU Optometer and the Focometer were neither clinically nor statistically different. Objective spherical equivalent findings with the Auto-refraction system showed a mild shift towards myopia when compared with the PolyU Optometer or Focometer findings. While PolyU Optometer findings were not significantly different from Auto-refraction system, Focometer findings were significantly different from Auto-refraction system. Although both the Focometer and the PolyU Optometer are portable instruments, the PolyU Optometer (90 grams) weighs substantially less than the Focometer (500 grams).

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