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ORIGINAL ARTICLE

# Self-refraction Accuracy with Adjustable Spectacles among Children in Ghana

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## ABSTRACT

***Purpose.*** To determine the accuracy of self-refraction (SR) in myopic teenagers, we compared visual and refractive outcomes of self-refracting spectacles (FocusSpecs) with those obtained using cycloplegic subjective refraction (CSR) as a gold standard.

***Methods.*** A total of 203 eligible schoolchildren (mean [±SD] age, 13.8 [±1.0] years; 59.1% were female) completed an examination consisting of SR with FocusSpecs adjustable spectacles, visual acuity with the logMAR (logarithm of the minimum angle of resolution) chart, cycloplegic retinoscopy, and CSR. Examiners were masked to the SR findings. Wilcoxon signed rank test and paired Student *t* test were used to compare measures across refraction methods (95% confidence intervals [CIs]).

***Results.*** The mean (±SD) spherical equivalent refractive error measured by CSR and SR was −1.22 (±0.49) diopters (D) and −1.66 (±0.73) D, respectively, a statistically significant difference of −0.44 D ($p < 0.001$, $t = 15.517$). The greatest proportion of participants was correctable to visual acuity greater than or equal to 6/7.5 (logMAR 0.1) in the better eye by CSR (99.0%; 95% CI, 96.5 to 99.7%), followed by cycloplegic retinoscopy (94.1%; 95% CI, 90.0 to 96.6%) and SR (85.2%; 95% CI, 79.7 to 89.5%). These proportions differed significantly from each other ($p < 0.001$, Wilcoxon signed rank test). Myopic inaccuracy of greater than 0.50 D and greater than or equal to −1.00 D was present in 29 (15.3%) and 16 (8.4%) right eyes, respectively, with SR. In logistic regression models, failure to achieve visual acuity greater than or equal to 6/7.5 in right eyes with SR was significantly associated with age (odds ratio, 1.92; 95% CI, 1.12 to 3.28; $p = 0.017$) and spherical power (odds ratio, 0.017; 95% CI, 0.005 to 0.056; $p < 0.001$).

***Conclusions.*** Self-refraction offers acceptable visual and refractive results for young people in a rural setting in Ghana, although myopic inaccuracy in the more negative direction occurred in some children.
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Key Words: self-refraction, cycloplegic retinoscopy, subjective refraction, adjustable spectacles

Refractive conditions continue to be a leading cause of blindness worldwide and the most prevalent cause of disabling visual disorder in the pediatric population, accounting for about 55 to 93% of visually impaired children.[1–6] Among this group, schoolchildren are highly vulnerable because poor vision can lead to reduced participation in classroom activities leading to increased absenteeism, increased dropout rates, reduced ability to learn, and poorer career prospects.[7] This is especially true for myopia, which is strongly associated with self-reported poor visual function and also has been implicated as a risk factor for poor academic performance.[8,9]

Population-based studies have shown that uncorrected refractive error is responsible for most poor vision among schoolchildren in Ghana. Among 152 eyes of Ghanaian schoolchildren, more than 71.7% of visual impairment (visual acuity <6/18 in the better eye) was caused by inadequately corrected refractive error.[10] This magnitude is expected to increase as additional resources are directed toward achieving gross enrollment targets in primary education by 2015. Unfortunately, professionals with the skill to accurately provide refractive services are in short supply considering the multitude of people requiring this service in the country. The situation is particularly critical in low-income settings where up to 94% of those visually impaired owing to uncorrected refractive error do not have

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access to corrective spectacles[11] because of issues related to high cost of spectacles and nonaffordability.[12,13] Given the potentially adverse developmental effects of uncorrected significant refractive errors, it is critical that an effective and sustainable system is put in place to deliver vision correction to those who cannot obtain or afford the services. Although there are many obstacles to implementing such a system, overcoming the dearth of trained staff and affordable spectacles may be the greatest challenge. The situation is similar in many of the sub-Saharan countries of Africa.

Spectacles with a variable spherical power whose design allows for sphere power adjustment by the user while wearing the spectacles may offer a feasible solution to this problem. These devices exist in two categories: the Adspec design uses fluid-filled lenses, wherein fluid is injected or removed into a bladder-like sac to change the power of the lens system, and the Alvarez optics design uses two lens systems that move relative to each other in a spectacle frame, causing changes in lens power. The Alvarez-based adjustable glasses are available from "FocusSpecs," "Adlens," and "Eyejusters."[14–16] Details of the optical principles and design of adjustable-focus lenses based on the Alvarez principle have been described elsewhere.[17]

In the last decade, there has been increasing interest in trying these devices in country programs in developing countries. Such trials have been carried out with identical protocols in the Boston[18] and urban[19] and rural China[20] self-refraction (SR) studies and suggested that good vision can be attained. However, these countries and Ghana differ significantly in various socioeconomic dimensions, such as education, health care, and infrastructure. Hence, although the self-adjustable spectacles may be accurate for SR among children in Boston and China, its validity in young people in Ghana is yet to be proven. The earlier study in Ghana examined the benefit of adjustable spectacles for near vision, but the study only had a small group of 16 participants aged older than 40 years.[21] For this reason, we compared the visual acuity and refraction results obtained by myopic teenagers in Ghana after self-correction with adjustable spectacles (FocusSpecs) with conventional methods of refraction, that is, subjective refraction after cycloplegic retinoscopy (CR) by a qualified eye care practitioner.

# METHODS

## Ethical Considerations

The study was conducted between April 6 and May 30, 2014, and adhered to the tenets of the Declaration of Helsinki. Research and ethics clearance was obtained from the ethics committee of the University of Cape Coast, Ghana. The protocol of the study was approved by the Cape Coast District Education Service; informed written consent was obtained from the parents and school authorities after the study was described and risks and benefits of participation were outlined. Participation was free and voluntary and only children whose parents approved the consent forms were examined.

## Study Participants

The study participants were recruited from public junior high schools (JHS) in the Komenda-Edina-Eguafo-Abrem (KEEA) Municipality, Central Region of Ghana. The KEEA Municipality is a rural and socioeconomically deprived area in the Central Region of Ghana, and most of the population are predominantly fishermen; as a result, academic standards in schools in the area are low.[22] Eye care or refraction services are offered in only one small private optical shop at prohibitive prices, leaving most of the indigenes who cannot afford the cost of care to resort to traditional eye medications in the form of herbs and leaf extracts, salt solution, and breast milk into their eyes when they experience vision problems.

## Sampling Procedure

Schoolchildren aged 12 to 15 years were selected from 18 public JHS in the KEEA. The educational system in the public schools is based on the idea of universal basic education, which is free and compulsory under the 1992 Constitution of Ghana. There exist a total of 47 public JHS grouped into six circuits by the KEEA District Directorate of Education.[23] Circuits were considered as clusters from which two schools were selected at random from a sampling frame of three schools or more in each circuit. A total of 18 schools were selected. An eye screening was conducted on all the children aged 12 to 15 years who were present at each selected school to identify those who met the eligibility criteria for inclusion into the study.

## Inclusion/Eligibility Criteria

The following were the criteria for inclusion into the study: age range 12 to 15 years with uncorrected visual acuity less than or equal to 6/12 in at least one eye, best-corrected visual acuity (BCVA) greater than or equal to 6/7.5 in both eyes by subjective refraction, myopia greater than or equal to −1.00 D but less than −5.00 D in one or both eyes, astigmatism less than or equal to −2.00 D in one or both eyes, and no ocular pathologies, strabismus, or amblyopia.

## Procedures

### *Visual Acuity Measurement*

Distance visual acuity measurements at 4 m using a retro-illuminated logarithm of the minimum angle of resolution (logMAR) chart with tumbling-E optotypes (Precision Vision, La Salle, IL) under natural illumination (as there was no electricity) were performed by doctors of optometry (optometrists). Starting on the top (6/60) line, testing progressed sequentially to the lowest line on which at least four of five letters were correctly identified. The right eye was measured first, followed by the left eye, each time occluding the fellow eye using a black plastic occluder with the concave surface placed over the eye. The participant was asked to keep the occluded eye open, if possible, during the procedure. Research assistants prevented children from leaning forward or backward in the chair and narrowing the palpebral fissure in the tested eye. Visual acuity was determined by the lowest line on which the participant read four out of five letters correctly.

### *Self-refraction*

Self-refraction spectacles used in this study (FocusSpecs) are made up of the following features: solid hinges that connect the temples to the eye rims of the frame, adjustment wheels that are turned to adjust the lenses, a lens indicator that is used as a reference point for the position of the adjustment lens, and spherical refractive minus powers ranging from −1.00 to −5.00 that can be obtained by instrument specifications, but no cylindrical lenses.

Each participant was made to perform SR with the adjustable spectacles in the eye with visual acuity less than or equal to 6/12, each time occluding the fellow eye. After giving instructions about the procedure as outlined in the manufacturer's instruction manual, the participants were asked to turn the wheel slowly back and forth until the letters on the vision chart became as clear as possible and then to fine-tune the adjustments slowly in either direction to refine the visual acuity. After SR, a portable battery-operated handheld focimeter was used to measure the power of each lens.

Self-refraction was supervised by the research assistants and class teachers. Before the commencement of SR procedures, all respective class teachers and research assistants were made to participate in a brief training workshop where the study protocol was received and practiced. Self-refraction was performed twice for each participant, and if there was an improvement in the best acuity from the second measurement, it was accepted as the final result. The entire measurement protocol was repeated for the other eye, and the visual acuities were recorded.

### *CR and Subjective Refraction*

Distance retinoscopy was performed under cycloplegia induced with two drops of 1% cyclopentolate administered 5 minutes apart in each eye. Thirty minutes after the last drop, retinoscopy was performed for an average duration of 5 minutes for each child. Trial lenses were used to neutralize the retinoscopy reflex to determine the refractive error present. The optometrists performing retinoscopy were masked to the results of SR. In addition, the visual acuity through the retinoscopic result was measured with a chart with an identical layout but with a different sequence of letters from those that have already been used in the study. Retinoscopy was immediately followed by monocular and binocular subjective refraction to determine the refractive correction that provided the best-corrected acuity. The best vision sphere was the least minus lens providing best acuity. The starting point for monocular subjective refraction was based on the retinoscopic end point; hence, subjective refraction could not be masked to the results of retinoscopy. Binocular subjective refraction was performed in a similar way to monocular subjective refraction, except that the fellow eye was not occluded.

### *Media and Fundus Examination*

In eyes with visual acuity less than or equal to 6/12, media and fundus examination was carried out using a handheld slit lamp biomicroscope and a direct and indirect ophthalmoscope after pupillary dilation. Participants with ocular abnormalities were withdrawn from the study and referred for care as needed.

### Statistical Methods

Visual acuity in the better- and worse-seeing eye was measured for uncorrected vision and with correction by SR, CR, and cycloplegic subjective refraction (CSR). Wilcoxon signed rank test was used to assess differences in the proportion of participants achieving BCVA of greater than or equal to 6/7.5 in the better eye across methods of refraction. Multiple regressions were used to analyze the association of age, sex, spherical error, and cylindrical power with failure to achieve a BCVA of greater than or equal to 6/7.5 with SR in the right eye among children with uncorrected visual acuity less than or equal to 6/12.

Measures of refraction across methods were analyzed by using spherical equivalent refractive error (SE). Paired Student *t* tests were used to compare SE measures across methods of refraction (95% confidence intervals [CIs]). Box plots were used for graphical representations of the distribution of SE across the methods of refraction. Accuracy of SR compared with CSR and CR was graphically illustrated using Bland-Altman plots.[24] Multiple logistic regressions were also used to analyze the association of age, sex, spherical error, and cylindrical error with SR measures that differed by greater than or equal to −1.00 D from the CSR.

Analyses were performed with SPSS program for Windows (version 16.0; SPSS Inc, Chicago, IL). Level of statistical significance was set at a p value of less than or equal to 0.05 (95% CI), and level of clinical significance was set at greater than or equal to 0.50 D difference in mean SE power between refraction methods.

## RESULTS

A total of 1660 schoolchildren attending 18 public schools were available for vision screening, and of these, 225 (13.6%) were found eligible on the basis of having uncorrected visual acuity less than or equal to 6/12 in one eye or in both eyes. Of the 225 otherwise eligible, 5 subjects were excluded because they could not achieve a BCVA of 6/7.5 in the worse-seeing eye owing to macular toxoplasma scar (3 subjects) and optic disc atrophy (2 subjects) detected on dilated fundus examination. Four subjects were excluded for lack of cooperation that prevented SR, 7 withdrew consent, and 6 others did not complete all of the testing because of scheduling constraints. The 203 remaining eligible schoolchildren, all of whom completed the entire study protocol, form the basis for remaining analyses unless otherwise stated. They were all myopes with a mean (±SD) age of 13.8 (±1.0) years; 120 (59.1%) were female.

Table 1 shows the distribution of visual acuity obtained without correction and with correction by the different methods of refraction. None of the subjects owned or wore corrective spectacles at the time of the study, and only 9.3% of the subjects achieved visual acuity of greater than or equal to 6/7.5 in the better-seeing eye with uncorrected vision. Uncorrected mean visual acuity for the better- and worse-seeing eye was logMAR 0.31 and logMAR 0.37, respectively.

The proportion of subjects correctable to visual acuity greater than or equal to 6/7.5 for each method of refraction is given in Fig. 1. The greatest proportion of subjects was correctable to greater than or equal to 6/7.5 in the better-seeing eye by CSR (99.0%; 95% CI, 96.5 to 99.7%), followed by CR (94.1%; 95% CI, 90.0 to 96.6%) and least by SR (85.2%; 95% CI, 79.7 to 89.5%). These proportions differed significantly from each other ($p < 0.001$, Wilcoxon signed rank test). Among 190 children with uncorrected visual acuity of less than or equal to 6/12 in

**TABLE 1.**

Distribution of visual acuity without correction and with various methods of refraction among study participants

| Snellen VA, logMAR | Uncorrected VA | | VA with SR | | VA with CR | | VA with CSR | |
|---|---|---|---|---|---|---|---|---|
| | Better eye | Worse eye | Better eye | Worse eye | Better eye | Worse eye | Better eye | Worse eye |
| 6/6 (0.00) | 11 (5.4) | — | 121 (59.6) | 120 (59.1) | 173 (85.2) | 159 (78.3) | 193 (95.1) | 183 (90.1) |
| 6/7.5 (0.10) | 8 (3.9) | — | 52 (25.6) | 55 (27.1) | 18 (8.9) | 19 (9.4) | 8 (3.9) | 12 (5.9) |
| 6/9.5 (0.20) | 4 (2.0) | — | 23 (12.8) | 25 (12.3) | 9 (4.4) | 14 (6.9) | 2 (1.0) | 7 (3.5) |
| 6/12 (0.30) | 124 (61.1) | 123 (60.6) | 6 (3.0) | 1 (0.5) | 2 (1.0) | 5 (2.5) | | 1 (0.5) |
| 6/15 (0.40) | 43 (21.2) | 46 (22.7) | — | — | | 3 (1.5) | | |
| 6/19 (0.50) | 9 (4.4) | 15 (7.4) | 1 (0.5) | 2 (1.0) | 1 (0.5) | 3 (1.5) | | |
| 6/24 (0.60) | 4 (2.0) | 8 (3.9) | — | — | | | | |
| 6/30 (0.70) | — | 4 (2.0) | — | — | | | | |
| 6/38 (0.80) | — | 7 (3.4) | — | — | | | | |
| Median VA | 6/12 (0.30) | 6/12 (0.30) | 6/6 (0.00) | 6/6 (0.00) | 6/6 (0.00) | 6/6 (0.00) | 6/6 (0.00) | 6/6 (0.00) |
| Mean VA | 0.31 | 0.37 | 0.06 | 0.06 | 0.03 | 0.04 | 0.01 | 0.01 |

Data are presented as number (percentage). Distribution of visual acuity (VA) in the better-seeing eye achievable by any of the three refractive techniques, namely, SR, CR, and CSR, was significantly different compared with the others ($p < 0.001$, Wilcoxon signed rank test).

the right eye, 35 (18.4%) failed to reach BCVA of 6/7.5 with SR, 18 (9.4%) with CR, and 5 (2.6%) with CSR. In logistic regression models (Table 2), predictors for failing to achieve a BCVA of greater than or equal to 6/7.5 included increasing age (odds ratio [OR], 1.92; 95% CI, 1.12 to 3.28; $p = 0.017$) and higher spherical power (OR, 0.017; 95% CI, 0.005 to 0.056; $p < 0.001$).

There was a strong correlation between mean SE measures in the right and left eye across all three refraction methods (Pearson correlation coefficient; CSR, $r = 0.896$; SR, $r = 0.895$; CR, $r = 0.914$), indicating symmetry in data collected from both eyes independently. Therefore, the analyses that follow are limited to the right eye. The distribution of spherical equivalent refractive error in the right eye by method of refraction is shown in Fig. 2. The mean (±SD) SE measured by SR was −1.66 (±0.73) D with a range of −1.00 to −5.00 D, the mean (±SD) SE measured by CSR was −1.22 (±0.49) D with a range of −1.00 to −4.50 D, and the mean (±SD) SE measured by CR was −1.35 (±0.59) D with a range of −1.00 to −5.00 D. Bland-Altman plots depicting each technique's deviation from CSR are shown in Fig. 3. The difference between CSR and SR was significant (paired $t$ test, $t = -15.517$, $p < 0.001$), with a mean difference of −0.44 D and a 95% limit of agreement between −1.20 and +0.33 D. The difference between CR and SR was also significant ($p < 0.001$, $t = -14.084$), with a mean difference of −0.32 D and a 95% limit of agreement between −0.92 and +0.29 D. Again, the difference between CSR and CR was significant ($p < 0.001$, $t = -8.114$), with a mean difference of −0.12 D and a 95% limit of agreement between −0.54 and +0.29 D. Box plot representation of the difference between SR and subjective refraction for different levels of subjective refractive error is shown in Fig. 4. Myopic inaccuracy of greater than −0.50 D and greater than or equal to −1.00 D was present in 29 (15.3%) and 16 (8.4%) right eyes, respectively, for SR compared with CSR. In the logistic regression model (table not shown), having SR measurements that differed by greater than or equal to −1.00 D from the subjective refraction power was significantly associated with higher spherical power (OR, 0.11; 95% CI, 0.04 to 0.30; $p < 0.001$).

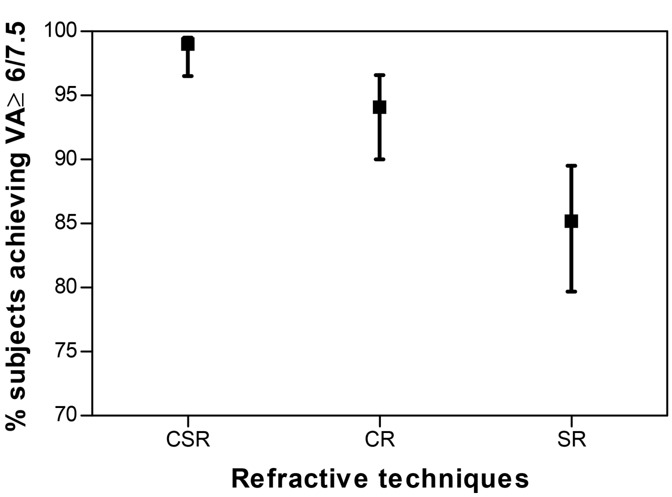


**FIGURE 1.**

Proportion of subjects correctable to visual acuity greater than or equal to 6/7.5 by technique, with 95% CI.

## DISCUSSION

Improved visual outcome with SR has been shown in this study. About 84% of the rural children self-corrected to optimum vision capable of achieving classroom success. Before intervention, most of the children reported a history of difficulty with reading off

**TABLE 2.**

Logistic regression model of factors associated with failure to achieve a BCVA of 6/7.5 with SR in the right eyes of participants

| Covariates | OR | 95% CI | p |
|---|---|---|---|
| Age | 1.92 | 1.12–3.28 | 0.017 |
| Spherical power, D | 0.017 | 0.005–0.056 | <0.001 |
| Male sex | 0.20 | 0.70–5.98 | 0.195 |
| Cylindrical error | 1.35 | 0.13–13.86 | 0.803 |

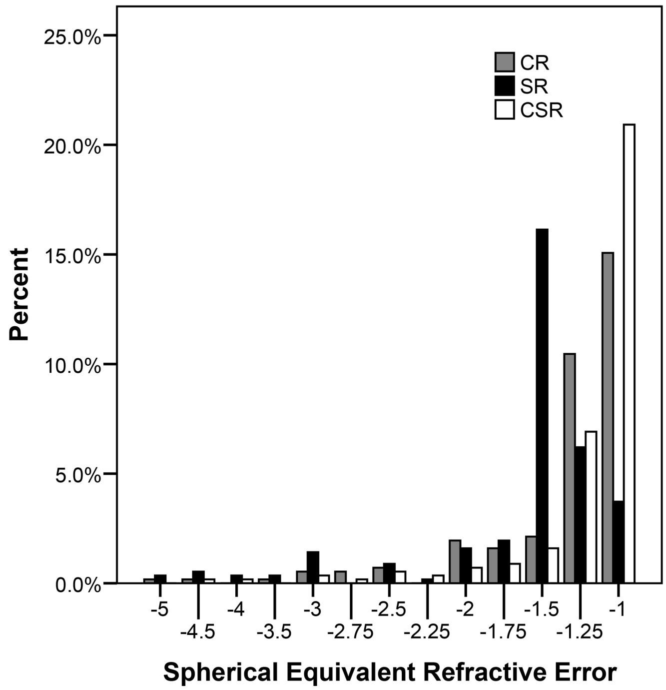


**FIGURE 2.**

Distribution of spherical equivalent refractive error in the right eye across methods of refraction.

chalk-written prints from their classroom blackboard. This signifies that, in Ghana, refractive error represented a significant cause of needless visual impairment in this population. Our results compare with the results in urban China,[19] where about 92% of the participants self-corrected to visual acuity greater than or equal to 6/7.5, and in rural China,[20] where about 97% attained similar vision. Only about 15.8% of 524 children in urban China self-corrected to visual acuity worse than 6/7.5, which is slightly lower than 18.4% with similar vision in our sample. The corresponding proportions were far lower in Boston (1.28%)[18] and rural China (4%).[20] However, when comparing SR results across studies, inequalities in socioeconomic and spectacle wear status of study participants should be noted. In the urban China[19] and Boston[18] studies, for example, participants were from high socioeconomic backgrounds and nearly half of those examined already owned corrective spectacles, whereas our pediatric sample was drawn from a fishing community in Ghana where conventional refractive services are almost nonexistent, and none of the participants had been refracted before; the setting in which SR is most relevant though. It is suggested that children not habitually wearing spectacles were at greater risk for less accurate results with SR possibly because such children are more tolerant of imperfectly corrected visual acuity and were thus less inclined to carefully adjust the self-refracting spectacles until optimal visual acuity had been achieved.[19] It would seem likely that the nonspectacle wear status of our study participants limited the visual outcome that should have been achieved with the self-adjustable spectacles.

The visual outcomes determined by subjective refraction and CR were better than those by SR. The results are similar in most SR studies and the reason is not far-fetched. Subjective refraction and CR included correction for astigmatism; it is expected that the

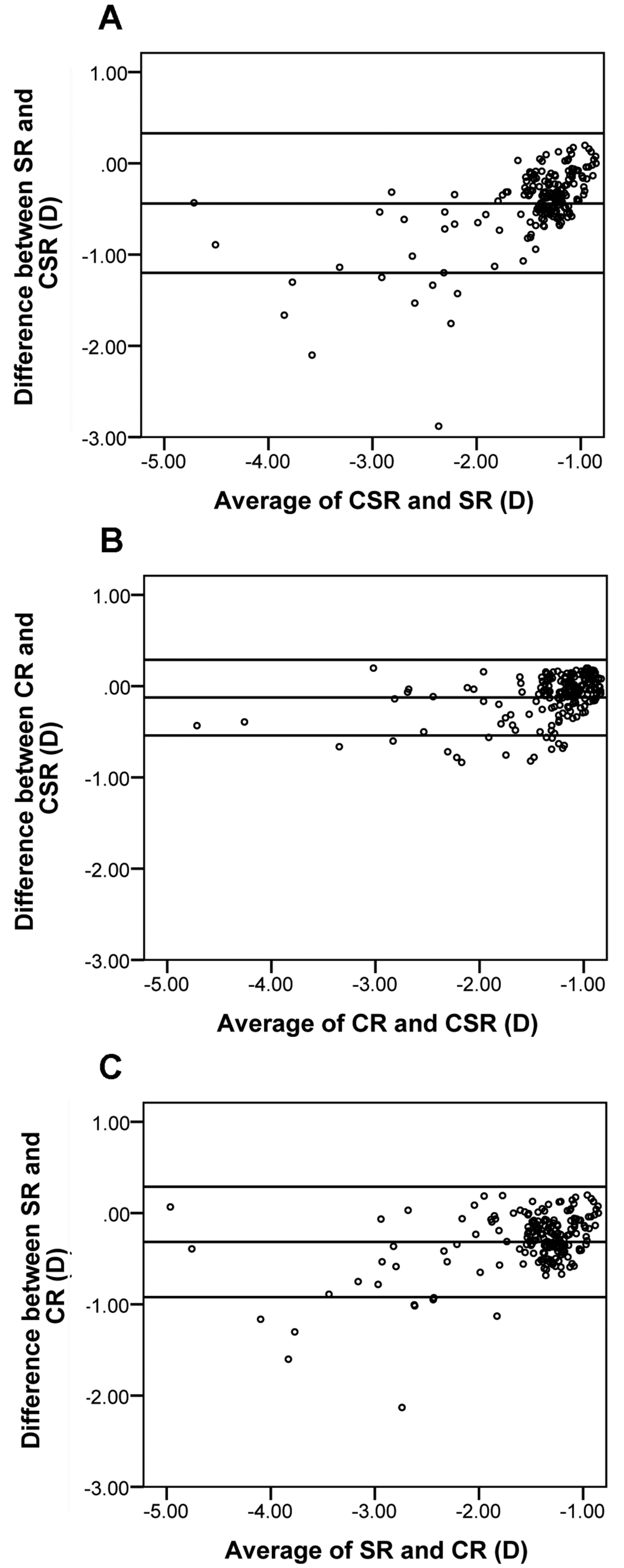


**FIGURE 3.**

Bland-Altman plots comparing refractive measurements between (A) SR and CSR, (B) CR and CSR, and (C) CR and SR. Difference between the measurements is plotted on the vertical axis, and their mean is plotted on the horizontal axis. The middle horizontal line represents the mean difference and the two horizontal lines, one above and the other below, are the 95% limits of agreement between measurements.

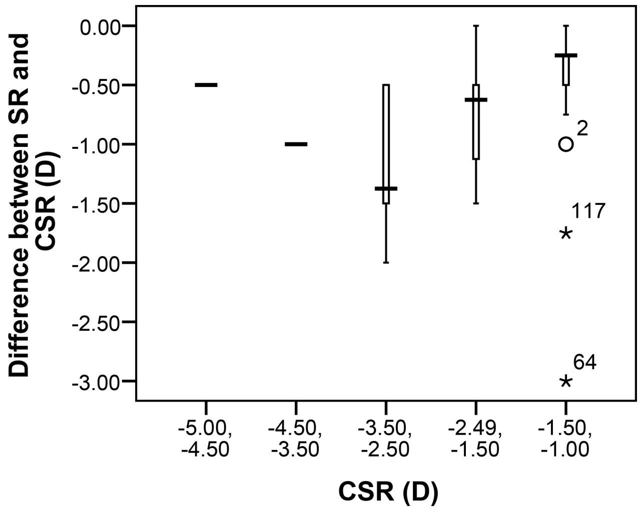


**FIGURE 4.**

Box plot representation of the difference between SR and CSR for different levels of refractive error. The box represents the mid-50%, the black bar in the box is the median, and the two whiskers below and above the box are the lower and upper quartile, respectively.

BCVA determined by subjective refraction would be better than that found by SR. It should be noted, however, that this difference represents only 35 of 203 children in our sample. It is interesting, though, to note that, in some studies,[25] the lack of astigmatic correction in the self-adjustable spectacles did not have a significant negative impact on the BCVA, as the BCVA values were comparable to those obtained by subjective refraction.

In contrast to other reports, refractive accuracy in this study was a mean −0.44 D over-minused for SR compared with CSR. This value, though higher than what was found in previous studies, was not clinically significant on average. Again, as noted previously, it can be argued that because the children have not habitually worn spectacles before, they were at risk of large measurement errors. However, it was impressive to note that most (about 92%) of the rural children in our sample were able to assess their refractive errors to within 1.00 D margin of error using the adjustable spectacles for the first time, which compares favorably with the corresponding proportion of 95% in rural China.[20] In many types of noncycloplegic refractive error measurement, a large proportion of the myopic bias is caused by accommodation. Refraction under cycloplegic conditions provides a more reliable estimate of the true refractive error present in children. Additional evidence can be found in the literature indicating a strong relationship between noncycloplegic methods for refraction in children and myopic bias.[26]

Cycloplegic retinoscopy is another modality most likely to be used in our part of the world for prescriptive measurement in uncooperative and noncommunicative patients, those with functional vision problems, or those whose visual acuity cannot be corrected to an expected level. Auto-refraction is least likely to be used in our setting. Results indicate that CR provides a more accurate measure of refractive error compared with SR, although the mean difference (−0.31 D) between the two methods was clinically insignificant. If so, the self-adjustable devices should be used with caution in areas where refractive services are adequate.

We also observed that the limits of agreement between subjective refraction and SR described a wide range of disagreement, in contrast to the previous studies[18–20] that reported a high degree of agreement between self-adjustable spectacles and conventional subjective refraction. The inconsistency of our findings with the previous studies emphasizes the difficulties of reaching definitive conclusions on the agreement between SR and subjective refraction. Further studies in a rural African population are needed to validate this finding. However, there is substantial evidence that accuracy of SR is dependent on learning. The repeatability study of du Toit et al.[27] concerning the use of the focometer suggests that the third measurement gives the most accurate measure of refractive error. It is possible that we may have had better results had the participants repeated SR thrice and used the final measurement as the best vision sphere. Accordingly, if these children are supplied with these adjustable glasses, nothing will prevent them from making further adjustments at any future time. That is a quite different situation from one in which a refractive error is determined and a static refractive power is prescribed. Thus, even with the over-minus correction, children who do continue to wear these glasses may learn to adjust the power in a way that best suits them in any particular situation. Nevertheless, when you consider the high proportion of children who achieved refractive accuracy of less than or equal to −0.50 (84.7%) and optimum vision via SR, the limits of agreement between both methods of refraction become less meaningful.

One notable finding of the current study is that higher cylindrical refractive error was not predictive of attaining poorer visual acuity with SR, although there were few significant cylindrical errors (16 eyes) in our sample. Findings from previous studies were consistent when evaluating predictors of failure to achieve optimal vision with SR. Report from rural[20] and urban China[19] indicated that higher spherical and cylindrical errors were predictive of achieving poorer visual acuity. Further studies are therefore recommended in this area.

The main objective of this study was to test the ability of teenaged children in Ghana to self-refract. However, we acknowledge some limitations of the study. The study sample was drawn from schools within only one municipality/district in Ghana and thus these results may not be generalizable to the rest of Ghana. It would have been ideal to conduct the current study among JHS pupils in some additional districts in Ghana, but this was not feasible for budgetary and logistical reasons. However, the earlier experience in Ghana[21] studied only 16 adults, and these data have been used to generalize the whole country for more than a decade. The KEEA Municipality was chosen partly because it is one of the poorest areas in Ghana, and this was done to increase participation rate, as children from a middle or high socioeconomic background typically do not participate in such exercise because they have the means and access to good eye care. Another practical limitation of the current study is that conventional subjective refraction was performed by two optometrists instead of the same optometrist. However, both optometrists hold a Doctor of Optometry degree and had many years of experience in refraction, which is reflected in the high interrater agreement between the examiners ($\kappa = 0.86$, $p = 0.012$). Literature suggests that interexaminer reliability of subjective refraction is reliable within 0.25 to 0.50 D.[28] Thus, we believe that the results were within the acceptable limits of reliability. To shorten waiting time and minimize fatigue that may have affected the accuracy of refraction and visual outcome, the use of two refractionists seemed to be the best approach after all. It is also worthy to note that the results of the current study may not necessarily be applicable to other models of self-adjustable devices.

Despite these potential limitations, the study is the first to assess the performance of self-adjustable glasses among a pediatric sample in a typical African setting, and as such our data might be helpful as a first step toward planning evidence-based refractive programs with self-adjustable devices in Africa. In summary, we have shown that self-correction of refractive error with the FocusSpecs adjustable spectacles offers good visual and refractive results even among young people in a rural setting in Ghana, although myopic inaccuracy in the more negative direction was present in some children. Bearing in mind the negative impact of over-minus correction, the adjustable devices need to be improved to ensure more accurate refraction results. Although the self-adjustable spectacles could be considered as an alternative to the standard prescribed spectacle correction where access to refractive services is limited, further studies are warranted to establish the stability of the refractive power with long-term use. The results of the current study support the need for deployment of self-adjustable glasses to developing countries like Ghana and also argue for improving access to refractive services through rational distribution of optometrists in Ghana.

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