



ORIGINAL ARTICLE

Vergence findings and horizontal vergence dysfunction among first year university students in Benin City, Nigeria



Godwin O. Ovenseri-Ogbomo*, Ovigwe Peter Eguegu

Department of Optometry, Faculty of Life Sciences, University of Benin, Benin City, Nigeria

Received 4 November 2015; accepted 18 January 2016

Available online 10 March 2016

KEYWORDS

Vergence
dysfunctions;
Convergence
insufficiency;
Phoria;
Fusional vergence;
University students

Abstract

Purpose: The study was designed to determine the prevalence of vergence dysfunctions among first year university students in Nigeria and to document the measures that define the vergence system of the visual system.

Methods: A cross-sectional study of first year students of the University of Benin, Benin City, Nigeria, who presented for the mandatory eye examination as part of their medical examinations required for clearance was conducted. A battery of tests that defines the vergence system including near and far phoria, positive and negative fusional vergence amplitudes at far and near, near point of convergence (NPC) and AC/A ratio were measured using conventional clinical protocols.

Results: The prevalence of vergence dysfunction among 212 first year university students who satisfied the inclusion criteria and gave consent to participate was 12.7%, with convergence insufficiency being the most common vergence dysfunction. Blurred vision, headache and diplopia were the most frequently reported visual symptoms.

Conclusion: There is a considerable prevalence of previously undiagnosed vergence dysfunctions in this population of students. The study underscored the need to carry out a thorough binocular vision assessment as part of the battery of tests administered to newly admitted students in this community to forestall any adverse effect the presence of vergence dysfunctions might have on the academic activity of university students.

© 2016 Spanish General Council of Optometry. Published by Elsevier España, S.L.U. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

* Corresponding author. Tel.: +234 8060962506.

E-mail addresses: godwin.ovenseri-ogbomo@uniben.edu (G.O. Ovenseri-Ogbomo), ovigwe.oe@gmail.com (O.P. Eguegu).

PALABRAS CLAVE

Disfunción de las vergencias;
Insuficiencia de convergencia;
Foria;
Vergencias fusionales;
Estudiantes universitarios

Resultados vergenciales y disfunciones de las vergencias horizontales entre los estudiantes universitarios de primer año de Benin City, Nigeria

Resumen

Objetivo: El estudio fue diseñado para determinar la prevalencia de las disfunciones de las vergencias entre los estudiantes universitarios de primer año en Nigeria, y documentar las mediciones que definen el sistema de las vergencias en el sistema visual.

Métodos: Se realizó un estudio transversal de los estudiantes de primer año de la Universidad de Benin, Benin City, Nigeria, que se presentaron a un examen ocular obligatorio como parte de las pruebas médicas requeridas a efectos de certificación. Se realizaron las mediciones necesarias para caracterizar el sistema de vergencias, incluyendo foria cercana y lejana, amplitudes de las vergencias fusionales positiva y negativa cercanas y lejanas, punto próximo de convergencia (NPC) y ratio AC/A, utilizando protocolos clínicos convencionales.

Resultados: La prevalencia de las disfunciones de la vergencia entre los 212 estudiantes universitarios de primer año que satisficieron los criterios de inclusión, y prestaron su consentimiento a participar, fue del 12.7%, siendo la insuficiencia de la convergencia la disfunción de las vergencias más común. Los síntomas visuales más frecuentemente reportados fueron visión borrosa, cefalea y diplopía.

Conclusión: Existe una prevalencia considerable de disfunciones de vergencias no diagnosticadas previamente en esta población de estudiantes. El estudio subrayó la necesidad de realizar una valoración profunda de la visión binocular como parte de la serie de pruebas realizadas a los nuevos estudiantes de esta comunidad, de cara a prevenir cualquier efecto adverso que pudiera producirse sobre la actividad académica de los estudiantes universitarios como consecuencia de la presencia de disfunciones de las vergencias.

© 2016 Spanish General Council of Optometry. Publicado por Elsevier España, S.L.U. Este es un artículo Open Access bajo la licencia CC BY-NC-ND (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Vergence dysfunctions describe a wide range of motor disorders of the visual system and includes convergence insufficiency, convergence excess, divergence insufficiency, divergence excess, decompensated heterophoria as well as inefficient and inaccurate pursuits and saccadic eye movements.¹ These binocular vision disorders are of particular significance during prolonged visual tasks such as reading. Whereas there is considerable evidence that individuals with binocular vision dysfunction experience significantly more visual symptoms associated with prolonged use of the eyes compared to those without binocular vision dysfunctions,²⁻⁴ there is however debate whether this association is important for reading performance^{5,6} and by extension for academic performance. Grisham et al.,⁴ demonstrated that there was an increase in the number of asthenopic complaints during reading compared to when not reading. They suggested that visual symptoms are a factor in reducing reading performance in symptomatic individuals.

During transition from high school to the university, there is a tendency for increased reading for considerably longer periods. This increased prolonged reading might have implications for individuals who have binocular vision dysfunctions. Porcar and Martinez-Palomera⁷ have reported that accommodative and non-strabismic binocular vision problems are prevalent in this population with a prevalence reported to be as much as 32.3% among university students.

Several studies⁸⁻¹³ have reported the prevalence of these dysfunctions in the general population and specific populations. These studies reported varying prevalence of both accommodative and vergence dysfunctions. The wide range of prevalence reported could be attributed to the different criteria used in the diagnosis of the various dysfunctions by the different authors as well as the differences in the study populations.

Whereas the prevalence of these dysfunctions is widely reported for Caucasian populations,^{7,9-11,13} we did not find any report for Nigerian populations. The paucity of data on the prevalence of binocular vision dysfunction in this part of the world may be related to the fact that the practice of optometry and the development of subspecialty in pediatric optometry is relatively new. It could also be due to the fact that primary eye care professionals rarely examine patients with a view to diagnosing vergence dysfunctions. As noted by Maino,⁸ "as primary eye care professionals we do not ask the right case history questions; we do not evaluate patients using the right tests; we do not make the diagnosis; and we do not treat or refer out for treatment these frequently encountered but often ignored disorders".

The present study was therefore designed to provide a preliminary data on the prevalence of vergence dysfunctions as well as document vergence findings among first year university students at the University of Benin, Benin City, Nigeria. A comparison between symptomatic and asymptomatic subjects is also reported.

Table 1 Diagnostic characteristics employed in the study.

Diagnosis ^a	Characteristics ^b
Basic exophoria	High exophoria, of the same magnitude at far and near
Basic esophoria	High esophoria of the same magnitude at far and near
Convergence excess	High esophoria, near > far, low NPC, high AC/A ratio (≥ 7)
Convergence insufficiency	High exophoria, near > far, receded NPC, low AC/A ratio (≤ 4)
Divergence excess	High exophoria, far > near
Divergence insufficiency	High esophoria, far > near

Data analysis was performed using SPSS version 21. Appropriate descriptive statistics were used to summarize the data obtained.

^a All the subjects diagnosed of having vergence dysfunctions presented with symptoms.

^b Based on the criteria specified by American Optometric Association.¹

Methods

A proposal to conduct the study was presented to the University of Benin and approval was obtained from the research committee of the Department of Optometry, University of Benin. First year students presenting for their medical and eye examinations were invited to participate in the study. Since the study was an exploratory study, all first year students admitted into the University of Benin in the 2012/13 academic year were eligible for the study. The purpose of the additional tests to be performed in addition to the battery of tests approved for the mandatory eye examination were communicated to volunteers who gave consent to participate in the study.

The examination procedure included a detailed case history with questionnaires for patient to report any visual symptoms they may have experienced especially when reading. Other clinical tests include visual acuity at distance and near, ocular health examination, subjective refraction, cover test, near point of convergence (NPC), distance and near phoria using von Graefe technique, positive and negative fusional vergence tests at distance and near as well as the accommodative convergence–accommodation ratio (AC/A ratio). The diagnosis of basic exophoria, basic esophoria, convergence excess, convergence insufficiency, divergence excess and divergence insufficiency in this study was based on the characteristics shown in Table 1.

Results

A total of 212 first year university students participated in the study. This comprised of 104 (49.1%) males and 108 (50.9%) females aged 15–28 years. The mean age of the subjects was 18.5 ± 2.2 years (95% Confidence Interval = 18.2–18.8 years). The mean age of the male subjects was 18.5 ± 2.3 years (95% Confidence Interval = 18.1–18.9 years) while that of the female subjects was 18.5 ± 2.0 years (95% Confidence Interval = 18.1–18.9 years). There was no significant difference between the ages of the male

Table 2 Gender and age distribution of study subjects.

Age group	Sex		Total
	Female	Male	
15–18	68 (63.0)	61 (58.7)	129 (60.8)
19–22	35 (32.4)	38 (36.5)	73 (34.4)
23–26	5 (4.6)	5 (4.8)	10 (4.7)
Total	108 (100.0)	104 (100.0)	212 (100.0)

$\chi^2 = 0.428$, $p = 0.807$.

and female subjects ($p = 0.977$). Table 2 shows the age distribution of the study subjects. There was no significant relationship between the subjects' age and their gender ($\chi^2 = 0.428$, $p = 0.807$).

Vergence findings

The phoria, vergence, NPC and AC/A results of the subjects are shown in Table 2. The mean distance phoria for the subjects was $-1.10 \pm 1.63^\Delta$ (that is 1.10^Δ exophoria) with a range of 6^Δ exophoria to 3^Δ esophoria for those without vergence dysfunction while for those with vergence dysfunction, the mean distance phoria was -1.04 ± 6.16 (that is 1.04^Δ exophoria). The range was between 13^Δ exophoria to 10^Δ esophoria for eyes with vergence dysfunction. Notwithstanding, there was no significant difference between the mean distance phoria for those who were diagnosed of vergence dysfunction and those without vergence dysfunction. Those with vergence dysfunction show a wide variation in the distance phoria. For near phoria, the mean was $-1.32 \pm 1.82^\Delta$ with a range from 6^Δ exophoria to 4^Δ esophoria for those without vergence dysfunction and $-0.67 \pm 7.39^\Delta$ and a range from 10^Δ exophoria to 12^Δ esophoria for those with vergence dysfunction. The mean NPC break and recovery was 6.11 ± 0.87 cm and 8.38 ± 1.02 cm respectively for those without vergence dysfunction, whereas for those with vergence dysfunction the respective values were 6.93 ± 4.06 and 8.93 ± 4.08 cm. The mean base in to blur/break/recovery at distance was $x/8.43/4.95$ (SD = $x/2.32/2.16$) for those without vergence dysfunction, while for those with vergence dysfunction the values were $x/10/6$ (SD = $x/2.43/1.96$). Similarly, the mean base out to blur/break/recovery at distance was $9.71/14.65/8.33$ (SD = $2.50/2.89/2.73$) for those without vergence dysfunction while for those with vergence dysfunction the mean values were $12.22/16.85/9.48$ (SD = $3.34/3.54/2.86$).

There was no significant difference between the values obtained in those with vergence dysfunctions and those without vergence dysfunctions for the measured variables except the positive and negative fusional vergence findings at distance (see Table 3).

Prevalence of vergence dysfunction

Of the total 212 subjects, 27 (12.7%) had vergence anomaly while 185 (87.3%) did not have vergence anomaly. Thus, the prevalence of vergence anomalies among first year university students in Benin City, Nigeria was 12.7%. This comprised

Table 3A Phoria, fusional vergence at 6 m of study subjects.

Vergence test	Vergence dysfunction	Minimum	Maximum	Mean $\pm$ SD	<i>p</i> -value
Distance phoria ^a	Absent	-6	3	-1.10 $\pm$ 1.63	0.956
	Present	-13	10	-1.04 $\pm$ 6.16	
BI to blur at 6 m ^b	Absent	0	0	0.000	0.001 ^c
	Present	0	0	0.000	
BI to break at 6 m	Absent	4	16	8.43 $\pm$ 2.32	0.018 ^c
	Present	6	16	10.00 $\pm$ 2.43	
BI to recovery at 6 m	Absent	2	10	4.95 $\pm$ 2.16	<0.0001 ^c
	Present	3	10	6.00 $\pm$ 1.98	
BO to blur at 6 m	Absent	1	18	9.71 $\pm$ 2.50	<0.0001 ^c
	Present	6	20	12.22 $\pm$ 3.34	
BO to break at 6 m	Absent	8	20	14.65 $\pm$ 2.89	<0.0001 ^c
	Present	12	28	16.85 $\pm$ 3.54	
BO to recovery at 6 m	Absent	2	18	8.33 $\pm$ 2.73	0.043 ^c
	Present	4	18	9.48 $\pm$ 2.86	

Table 3B Phoria, fusional vergence, NPC and AC/A ratio at 40 cm of study subjects.

Vergence test	Vergence dysfunction	Minimum	Maximum	Mean $\pm$ SD	<i>p</i> -value
Near phoria ^a	Absent	6	4	-1.32 $\pm$ 1.82	0.651
	Present	10	12	-0.67 $\pm$ 7.39	
BI to blur at 40 cm	Absent	4	18	10.08 $\pm$ 2.76	0.947
	Present	4	18	10.04 $\pm$ 3.06	
BI to break at 40 cm	Absent	8	24	15.44 $\pm$ 3.06	0.525
	Present	10	24	15.04 $\pm$ 3.30	
BI to recovery at 40 cm	Absent	4	18	9.17 $\pm$ 2.69	0.484
	Present	2	14	8.78 $\pm$ 3.02	
BO to blur at 40 cm	Absent	8	20	14.73 $\pm$ 3.33	0.162
	Present	6	22	13.74 $\pm$ 4.00	
BO to break at 40 cm	Absent	12	30	20.89 $\pm$ 3.90	0.095
	Present	12	28	19.56 $\pm$ 3.61	
BO to recovery at 40 cm	Absent	6	24	12.70 $\pm$ 3.97	0.200
	Present	4	18	11.67 $\pm$ 3.25	
NPC break	Absent	5	9	6.11 $\pm$ 0.87	0.306
	Present	3	15	6.93 $\pm$ 4.06	
NPC recovery	Absent	6	11	8.38 $\pm$ 1.02	0.497
	Present	5	17	8.93 $\pm$ 4.08	
AC/A ratio	Absent	4	8	5.84 $\pm$ 0.58	0.848
	Present	3	11	5.93 $\pm$ 2.23	

^a Negative phoria values indicates exophoria while positive values indicate esophoria.^b 0 indicates that the subject did not report a blur.^c Significant *p*-value.**Table 4** Distribution of vergence anomalies among the study subjects.

Diagnosis	Sex		Total
	Female	Male	
Basic esophoria	3 (23.1)	1 (7.1)	4 (14.8)
Basic exophoria	1 (7.7)	4 (28.6)	5 (18.5)
Convergence excess	3 (23.1)	3 (21.4)	6 (22.2)
Convergence insufficiency	3 (23.1)	5 (35.7)	8 (29.6)
Divergence excess	1 (7.7)	1 (7.1)	2 (7.4)
Divergence insufficiency	2 (15.4)	0 (0.0)	2 (7.4)
Total	13 (100.0)	14 (100.0)	27 (100.0)

(Fisher's Exact Test = 5.00, *p* = 0.464).

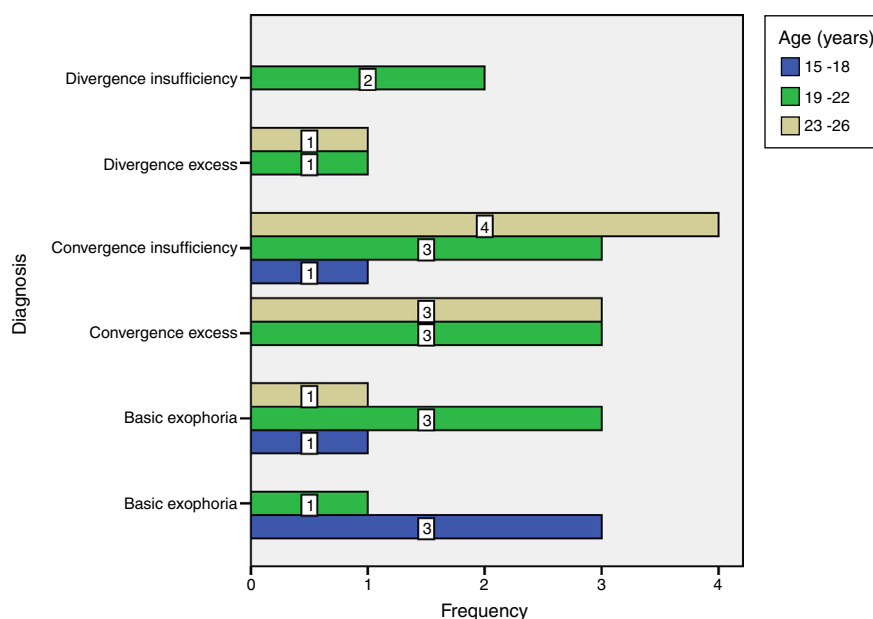


Figure 1 Distribution of vergence anomalies by age group.

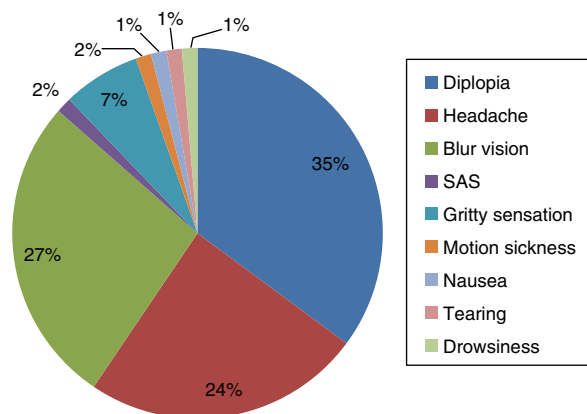


Figure 2 Distribution of symptoms reported by subjects who were diagnosed of having vergence anomalies (SAS, short attention span).

of 14 (51.86%) male and 13 (48.14%) female subjects (Odds Ratio = 1.137, 95% Confidence Interval = 0.507–2.550). Convergence insufficiency was the most common vergence anomaly found in the study followed by convergence excess (Table 4). The type of vergence dysfunction suffered by the subjects was independent of the sex of the study participants (Fisher's Exact Test = 5.00, $p = 0.464$).

In terms of age, 13 (48.1%) had vergence dysfunction within the 19–22 years age group followed by 9 (33.3%) in the age group 23–26 years and 5 (18.6%) in the age group 15–18 years (Figure 1).

The subjects who had vergence anomalies reported various symptoms including intermittent diplopia, headache, transient blur vision, etc. (Figure 2).

Discussion and conclusion

The present study documents the mean and range of values for vergence tests for a population of first year Nigerian

University students aged 15–28 years. It was difficult to compare the values obtained in this study with previously documented findings because of the differences in the age of subjects, sample size and population studied. Notwithstanding, cut-off for the break finding for the near point of convergence (NPC) would appear to be about 6 cm. This is similar to the value suggested as a clinical cut-off for NPC break for patients in elementary school.¹⁴ The authors remarked that using this cut-off for the general population may lead to high false-positive rates. A cut-off of 5 cm has been suggested by Maples and Hoenes.¹⁵ In the present study, symptomatic subjects had higher NPC break with a large variation compared to asymptomatic subjects though this difference was not statistically significant. Of all the measured variables, only the positive and negative fusional vergence amplitudes at far were significantly different for both symptomatic and asymptomatic subjects. It will also be noted that there were subjects with vergence dysfunction that reached a fusional vergence break of 16 $^{\Delta}$. While this may be theoretically implausible, it does reflect the fact that the presence of vergence anomaly is not only related to the magnitude of an individual finding with respect to decompensated phoria but also to the level of balance between the fusional vergence reserve relative to the phoria demand^{1,16} (1; 2). This abnormally high value of 16 $^{\Delta}$ may represent a normal variation in the general population. The mean value of the fusional vergence break however is reflective of the expected normative findings.

The lack of difference between subjects with and without vergence dysfunctions may reflect the fact that no one single diagnostic criteria is sufficient in adequately classifying subjects who have vergence anomaly. It may also be indicative of the fact that vergence dysfunction occurs more frequently as a syndrome where more than one clinical entity coexist in eliciting symptoms. For example, convergence insufficiency often coexists with accommodative insufficiency and the later has been found to be the primary source of symptoms when both conditions coexist.¹⁷ The implication therefore

is that in evaluating a patient with symptoms suggestive of binocular vision anomaly, both the vergence and accommodative systems should be thoroughly reviewed.

The prevalence of vergence dysfunctions amongst first year university students of a Nigerian University was 12.7% with almost equal prevalence in male and female subjects. Convergence insufficiency was the most common vergence finding followed by convergence excess and basic exophoria.

Most literature surveyed on the prevalence of vergence dysfunctions reported the total prevalence of accommodative and vergence dysfunctions together.^{7,9–11,13,17,18} The prevalence of convergence insufficiency in this study was 29.6%. This is much lower compared to 61.4% reported by Duam¹⁸ but more than values reported by other authors.^{7,9–11,13,17,19} The wide range of prevalence of convergence insufficiency and other vergence dysfunctions reported in the literature reflects the variation in the diagnostic criteria employed, the sample size as well as the population studied – whether they are clinic population, general population or a population of students. It is also influenced by the age group studied, depending if it is a population of children or adults.

Diplopia and headache were the most frequently reported symptoms by subjects diagnosed with vergence dysfunction in the present study. In addition to blur vision, these accounted for 86% of patients' complaints. This is higher compared to 38.5% reported by Porcar and Palomera⁷ and 33.8% reported by Montes-Mico.¹¹ These symptoms may have serious implications for academic activities by university students. They are capable of preventing the student from studying for long period of time. A limitation in this study in respect of the report of headache as a symptom is the fact that no further history were undertaken to rule out other causes of headache. However, since the question posed to the respondents was that they should report the symptoms they have during reading, one could assume that these symptoms were related to the use of the eyes. Similarly, the report of diplopia in the present study may present some limitations. Besides vergence anomalies, other motor anomalies of the visual system could cause diplopia. These causes were not evaluated in the present study.

Curiously, none of the symptomatic subjects in this study have presented for an eye examination prior to this study. When asked what action they took when these symptoms of binocular anomalies arose, majority of the subject claimed to take a break from their studies to relax the eyes. Some often dismiss the symptoms as being due to other stressful activities such as going from one lecture venue to the other.

In conclusion, the study finds a considerable prevalence of previously undiagnosed vergence anomalies, with convergence insufficiency being the predominant anomaly. The symptoms reported have the potential to affect academic activities of the students. The findings suggest that a thorough eye examination to detect binocular vision anomalies should be administered to university students in order to promote an efficient visual system for adequate educational activities.

Conflicts of interest

The authors have no conflicts of interest to declare.

References

1. American Optometric Association. *Optometric Clinical Practice Guideline: Care of Patient with Accommodative and Vergence Dysfunction*. St. Louis: American Optometric Association; 1998.
2. Sheedy JE, Saladin JJ. Association of symptoms with measures of oculomotor deficiencies. *Am J Optom Physiol Opt*. 1978;55:670–676.
3. Yekta AA, Pickwell LD, Jenkins TCA. Binocular vision, age and symptoms. *Ophthal Physiol Opt*. 1989;9:115–120.
4. Grisham JD, Sheppard MM, Tran WU. Visual symptoms and reading performance. *Optom Vis Sci*. 1993;70:384–391.
5. Simons HD, Gassler PA. Vision anomalies and reading skills: a meta-analysis of the literature. *Am J Optom Physiol Opt*. 1988;65:893–904.
6. American Academy of Ophthalmology. *Policy Statement: Learning Disabilities, Dyslexia and Vision*. American Academy of Ophthalmology; 1984.
7. Porcar E, Martinez-Palomera A. Prevalence of general binocular dysfunctions in a population of university students. *Optom Vis Sci*. 1997;74:111–113.
8. Maino D. The binocular vision dysfunction pandemic. *Optom Vis Dev*. 2010;41:6–13.
9. Scheiman M, Gallaway M, Coulter R, et al. Prevalence of vision and ocular disease conditions in a clinical pediatric population. *J Am Optom Assoc*. 1996;67:193–202.
10. Hokoda SC. General binocular dysfunctions in an urban optometry clinic. *J Am Optom Assoc*. 1985;56:560–562.
11. Montes-Mico R. Prevalence of general dysfunction in binocular vision. *Ann Ophthalmol*. 2001;33:205–208.
12. Cacho-Martinez P, Garcia-Munoz A, Ruiz-Cantero MT. Do we really know the prevalence of accommodative and nonstrabismic binocular dysfunctions? *J Optom*. 2010;3:185–197.
13. Richman JE, Laudon RC. A survey of the prevalence of binocular and accommodative dysfunctions in a sample of optometry students. *J Behav Optom*. 2002;13:31–33.
14. Hayes GJ, Cohen BE, Rouse MW, DeLand PN. Normative values for nearpoint of convergence of elementary school children. *Optom Vis Sci*. 1998;75:506–512.
15. Maples WC, Hoenes R. Near point of convergence norms measured in elementary school children. *Optom Vis Sci*. 2007;84:224–228.
16. Evans BJW. *Pickwell's Binocular Vision Anomalies: Investigation and Treatment*. Oxford: Butterworth-Heinemann; 1997.
17. Marran LF, DeLand PN, Nguyen AL. Accommodative insufficiency is the primary source of symptoms in children diagnosed with convergence insufficiency. *Optom Vis Sci*. 2006;83:281–289.
18. Daum KM. Characteristics of exodeviations: II. Changes with treatment with orthoptics. *Am J Optom Physiol Opt*. 1986;63:244–251.
19. Lara F, Cacho P, Garcia A, Megias R. General binocular disorders: prevalence in a clinic population. *Ophthal Physiol Opt*. 2001;21:70–74.