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Prevalence of non-strabismic anomalies of binocular vision in Tamil Nadu: report 2 of BAND study

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Background: Population-based studies on the prevalence of non-strabismic anomalies of binocular vision in ethnic Indians are more than two decades old. Based on indigenous normative data, the BAND (Binocular Vision Anomalies and Normative Data) study aims to report the prevalence of non-strabismic anomalies of binocular vision among school children in rural and urban Tamil Nadu.

Methods: This population-based, cross-sectional study was designed to estimate the prevalence of non-strabismic anomalies of binocular vision in the rural and urban population of Tamil Nadu. In four schools, two each in rural and urban arms, 920 children in the age range of seven to 17 years were included in the study. Comprehensive binocular vision assessment was done for all children including evaluation of vergence and accommodative systems. In the first phase of the study, normative data of parameters of binocular vision were assessed followed by prevalence estimates of non-strabismic anomalies of binocular vision.

Results: The mean and standard deviation of the age of the sample were 12.7 ± 2.7 years. The prevalence of non-strabismic anomalies of binocular vision in the urban and rural arms was found to be 31.5 and 29.6 per cent, respectively. Convergence insufficiency was the most prevalent (16.5 and 17.6 per cent in the urban and rural arms, respectively) among all the types of non-strabismic anomalies of binocular vision. There was no gender predilection and no statistically significant differences were observed between the rural and urban arms in the prevalence of non-strabismic anomalies of binocular vision (Z-test, $p > 0.05$). The prevalence of non-strabismic anomalies of binocular vision was found to be higher in the 13 to 17 years age group (36.2 per cent) compared to seven to 12 years (25.1 per cent) (Z-test, $p < 0.05$).

Conclusion: Non-strabismic binocular vision anomalies are highly prevalent among school children and the prevalence increases with age. With increasing near visual demands in the higher grades, these anomalies could significantly impact the reading efficiency of children. Thus, it is recommended that screening for anomalies of binocular vision should be integrated into the conventional vision screening protocol.

Key words: accommodation, accommodative infacility, binocular vision, convergence, convergence insufficiency, non-strabismic binocular vision anomalies, normative data, school screening

Accommodative and non-strabismic anomalies of binocular vision are reported to be highly prevalent among school children with estimates of close to 30 per cent according to a recent population-based study.[1] To the best of our knowledge, there are no data in the Indian literature on the prevalence of non-strabismic anomalies of binocular vision. Convergence insufficiency due to its high prevalence in clinical[2,3] and community settings[4,5] has been the non-strabismic anomaly of binocular vision most emphasized in the literature. Hospital-based studies in India, report prevalence rates of convergence insufficiency from 3.6 to 7.7 per cent;[6,7] however, these data are more than a decade old. Also, the prevalence ranges in various studies vary between 2.25 and 33 per cent and this is likely due to the inconsistency in the diagnostic cut-off and criteria.[1–8] Physiological and environmental factors, such as ethnicity, have been shown to influence the diagnostic cut-off of a parameter. This suggests that using an indigenous diagnostic cut-off for a population would best represent the prevalence of non-strabismic anomalies of binocular vision in that particular population.[5,9–11]

It has been reported that a high proportion of children with convergence insufficiency also have learning difficulties and the academic behaviour, assessed using an 'academic behaviour survey' showed significant improvement following vision therapy for convergence insufficiency.[12,13] With the increasing near visual demands, it is important to study the current prevalence of non-strabismic anomalies of binocular vision among school children, so that appropriate intervention could be planned. Hence, the BAND (Binocular Vision Anomalies and Normative Data) study group[14] designed this study to investigate the prevalence of non-strabismic anomalies of binocular vision among school children in rural and urban Tamil Nadu.

METHODS

This study is part of an epidemiological project named BAND and the detailed methods are available in a previous publication.[14] This research was approved by the Institutional Review Board of Vision Research Foundation and adheres to the tenets of the Declarations of Helsinki. The field work for the study began in February 2014 and was completed by December 2015. Two schools each in rural and urban locations were identified, based on non-probability convenience sampling. A pilot study was done to estimate the sample size followed by epidemiological field work, including comprehensive eye examination and binocular vision assessment. With an estimated sample of 936,[14] four public schools, two each in the rural and urban arms of Chennai were selected. A total of 3,024 children between seven and 17 years of age were screened in the four schools and 920 children were included, based on simple random sampling. Estimates of normative data were done in the first phase followed by estimates of prevalence of non-strabismic anomalies of binocular vision, based on the cut-off derived from the normative data.[11]

The first phase of the study focused on identifying refractive errors and ocular abnormalities other than non-strabismic anomalies of binocular vision. Vision screening was performed using an Elite School of Optometry pocket vision screener with a cut-off of 6/9.5 (0.2 logMAR) visual acuity,[15] versions, pupillary assessment, stereo-acuity at near using Randot stereo-plates and a penlight examination for gross ocular abnormalities. Static retinoscopy and subjective refraction was performed using a logMAR chart for children with refractive errors. If a subject was found to have a significant refractive error for the first time (myopia of −0.50 DS or more, hyperopia +0.50 DS or more, astigmatism 0.50 D or more) or if a change in refractive error of more than 0.50 D was detected in the spherical or cylindrical component during the refraction, glasses were prescribed and the binocular vision assessment was repeated two weeks after wearing the spectacle prescription. Tolerance limits for refractive errors were adopted from the Convergence Insufficiency Treatment Trial (CITT) protocol.[16] Children with strabismus, amblyopia and other ocular abnormalities were excluded from the prevalence study and were referred to the base hospital. Children were also excluded if they had any previous intraocular/strabismus surgery, ocular or head trauma or juvenile diabetes. To be eligible for the next phase of the study children had to be seven to 17 years of age and have visual acuity better than or equal to 6/9 and N6.

Detailed assessment of binocular vision and accommodation

After the vision screening, all children had a comprehensive binocular vision and accommodative assessment that included the near point of convergence, phorias at distance and near, fusional vergence amplitudes, vergence facility, near point of accommodation, accommodative response and monocular (right eye only) and binocular accommodative facility. The detailed procedures for these tests are described in a previous publication.[14]

The diagnosis of non-strabismic anomalies of binocular vision was based on the criteria suggested by Scheiman and Wick[17] for convergence insufficiency, convergence excess, divergence insufficiency, divergence excess, basic esophoria, basic exophoria, fusional vergence dysfunction, accommodative insufficiency, accommodative excess and accommodative infacility. As a first step, the normative data for binocular vision and accommodation parameters for the paediatric Indian population were estimated from this population (unpublished data) and these cut-off points were used to establish the diagnosis (Appendix I).[11] Children who were symptomatic and met the inclusion criteria for any of the diagnoses for non-strabismic anomalies of binocular vision were included in the prevalence study.

Data measurement

Data analysis was performed using Microsoft Excel 2007 and SPSS-V.18.0. Descriptive statistics were calculated for all the anomalies of binocular vision and differences in proportions were analysed between the rural and urban populations. Similarly, differences in prevalence between the gender and age groups were analysed. Statistical comparisons were made using Z-test for proportions with the p-value cut-off of 0.05 for statistical significance.

RESULTS

A total of 3,024 children aged between seven and 17 years were screened in four schools and 920 children were included in the study. The mean age and standard deviation of the sample were 13.2 ± 2.3 and 11.6 ± 2.9 years in the rural and urban arms, respectively. The prevalence of refractive errors and ocular diseases are provided in Table 1.

The demographic details and the distribution of non-strabismic anomalies of binocular vision are represented in Table 2. There was no significant difference in the prevalence between rural and urban populations for the overall prevalence of non-strabismic anomalies of binocular vision or for the subtypes ($p > 0.05$, Z-test).

Convergence insufficiency was the most prevalent non-strabismic anomaly of binocular vision in both the rural and urban populations followed by accommodative infacility (Table 2). The proportion of non-strabismic anomalies of binocular vision was not statistically significant between the rural and urban populations. Hence for age-based analyses, the rural and urban data were analysed together. Two age groups of seven to 12 years and 13 to 17 years were identified, based on the previous analyses from normative data from the same population.[11]

Also, other than convergence insufficiency and accommodative infacility, other subtypes of non-strabismic anomalies of binocular vision showed prevalence close to one per cent and hence statistical analysis was restricted to convergence insufficiency and accommodative infacility due to adequate sampling. Age-based analyses of the prevalence of non-strabismic anomalies of binocular vision revealed a significant increase in prevalence in the 13 to 17 years age group and these results were statistically significant (Z-test, $p < 0.0001$). Similarly, statistically significant differences were observed for the subtypes of convergence insufficiency and accommodative infacility (Z-test, $p < 0.0001$) (Table 3).

As convergence insufficiency was the most prevalent non-strabismic anomaly of

	Rural N = 1,435	Urban N = 1,589
Refractive errors		
Myopia	28 (1.95%)	34 (2.1%)
Hyperopia	4 (0.3%)	8 (0.5%)
Astigmatism	18 (1.25%)	37 (2.3%)
Strabismus and amblyopia	7	2
Ocular diseases (list below)	16 (1.1%)	21 (1.3%)
Cataract	2	5
Nystagmus	1	5
Retinal pathology	4	5
Congenital colour blindness	4	0
Ptosis	1	4
Corneal disorders	1	2
Iris coloboma	1	0
Third nerve palsy	2	0

Table 1. Prevalence of refractive errors and ocular diseases

	Rural N = 358	Urban N = 562
Mean (SD) age	13.2 ± 2.3	11.6 ± 2.9
Male: female	185:173	324:238
Normal binocular vision	252 (70.4%)	385 (68.5%)
Overall non-strabismic anomalies of binocular vision	106 (29.6%)	177 (31.5%)
Convergence insufficiency	63 (17.6%)	93 (16.5%)
Convergence excess	6 (0.8%)	10 (1.4%)
Divergence excess	0	2 (0.4%)
Fusional vergence dysfunction	3 (0.8%)	5 (1.3%)
Divergence insufficiency	1	0
Basic esophoria	1 (0.3%)	0
Basic exophoria	0	0
Vergence infacility	0	2
Accommodative infacility	29 (7%)	64 (10.7%)
Accommodative excess	3 (0.8%)	0
Accommodative insufficiency	0	1 (0.2%)

Table 2. Prevalence of non-strabismic anomalies of binocular vision in the rural and urban populations

binocular vision among all the subtypes, followed by accommodative infacility, the mean values of the parameters of binocular vision in subjects with convergence insufficiency and accommodative infacility are listed in Table 4. These parameters were compared with the data of the normal binocular vision group, from the same population.[11] All the binocular vision parameters were significantly different between the convergence insufficiency and normal binocular vision group except for the monocular estimate method retinoscopic value, near vertical muscle imbalance measure, near and distance negative fusional vergences (unpaired t-test; $p < 0.0001$). As a high prevalence of accommodative insufficiency is reported as a co-morbid condition in convergence insufficiency,[10,18,19] we analysed the amplitude of accommodation in convergence insufficiency with the normal binocular vision group and the difference in amplitude of accommodation was found to be statistically significant (unpaired t-test, $p < 0.001$) but these results were clinically insignificant (mean amplitude of accommodation in convergence insufficiency: 10.5 ± 2.9; normal binocular vision: 11.8 ± 3.1; mean difference (95 per cent confidence interval [CI]): 1.3 D [0.7 to 1.9]). In the accommodative infacility group, monocular and binocular accommodative facility and near point of convergence with penlight/red filter (NPC-PLR) break and recovery values were significantly different from the normal binocular vision group (unpaired t-test; NPC-PLR, $p < 0.05$; accommodative facility – monocular and binocular, $p < 0.0001$).

As detailed in the methods, subjects who failed the screening criteria were referred for further management and subjects who passed the screening criteria were included in the study. Subjects who passed the comprehensive binocular vision assessment were included in the normative project. Subjects with visual symptoms and identified as having an anomaly of binocular vision based on the binocular vision assessment were included for the prevalence project. Yet, during this process, there were subjects who had an asymptomatic anomaly of binocular vision and others that were symptomatic but had normal binocular vision. These combinations were analysed and data from these subjects were reassessed prior to classifying them to one of the two groups of normal binocular vision versus non-strabismic anomalies of binocular vision. Seventy-three children (7.9 per cent) fell into one of these two groups. Fifty-eight (6.3 per cent) were asymptomatic but still failed the tests of binocular vision and were classified as having non-strabismic anomalies of binocular vision. Fifteen (1.6 per cent) were symptomatic but had normal parameters of binocular vision and were classified as normal binocular vision (Table 5).

DISCUSSION

Our study is the first to report the prevalence of non-strabismic binocular vision

	7–12 years n (%)	13–17 years n (%)
TOTAL SAMPLE	450	470
Normal binocular vision	337 (74.8)	300 (65.2)
Overall non-strabismic anomalies of binocular vision	113 (25.1)	170 (36.2)
Convergence insufficiency	66 (14.6)	90 (19.6)
Accommodative infacility	42 (9.3)	51 (11.1)

Table 3. Prevalence of non-strabismic anomalies of binocular vision in the seven to 12 years and 13 to 17 years age groups in the overall population

anomalies in the rural and urban populations in southern India. The prevalence of non-strabismic anomalies of binocular vision was estimated to be 31.5 and 29.6 per cent in the rural and urban populations, respectively. Among primary school children, recent population-based data in ethnic Asians reported a prevalence of 28.5 per cent of non-strabismic anomalies of binocular vision.[1] Similarly, in a clinical paediatric population, a previous study showed that non-strabismic anomalies of binocular vision are almost 8.5 to 9.7 times more common than the prevalence of

BV parameters		CI N = 156	AIF N = 93	Normative reference N = 637
Mean age, years		12.7 ± 2.7	12.6 ± 2.6	12 ± 2.8
NPC-AT, cm	BREAK	7.4 ± 5.2	3.5 ± 3.8	3 ± 3
	REC	9.5 ± 7.3	4.3 ± 4.7	4 ± 4
NPC-PLR, cm	BREAK	18.4 ± 10.8	9 ± 8	7 ± 5
	REC	23.5 ± 11.8	12.1 ± 10.3	10 ± 7
Amplitude of accommodation, D	M/O	10.5 ± 2.8	11.4 ± 3	7–10 years: 13 ± 3 11–17 years: 11 ± 2
	B/O	11 ± 3.3	12 ± 3	7–10 years: 13 ± 3 11–17 years: 11 ± 3
Near PFV, PD	BREAK	16.6 ± 7.6	23.6 ± 10.4	26 ± 10
	REC	12.8 ± 6.3	17.7 ± 8	21 ± 10
Near NFV, PD	BREAK	13.9 ± 4	14 ± 4.8	15 ± 4
	REC	11 ± 3.9	10.5 ± 4.2	11 ± 4
Distance PFV, PD	BREAK	12.1 ± 6	15.2 ± 5.8	17 ± 8
	REC	8.4 ± 5.2	11 ± 4.8	12 ± 7
Distance NFV, PD	BREAK	7.6 ± 2.8	8.3 ± 2.3	8 ± 2
	REC	5 ± 2.1	5.8 ± 2	6 ± 2
Accommodative facility, CPM	M/O	9.5 ± 5.6	4 ± 2	7–12 years: 11 ± 4 13–17 years: 14 ± 5
	B/O	9.8 ± 5.4	5.3 ± 2.7	7–12 years: 10 ± 4 13–17 years: 14 ± 5
Vergence facility, CPM		8.2 ± 5.4	11 ± 4.5	7–12 years: 12 ± 4 13–17 years: 14 ± 4
MIM-Horizontal, PD	DIST	–0.9 ± 2.1	0 ± 0.8	0.02 ± 1
	NEAR	–4.5 ± 3.9	–0.1 ± 1.8	–0.4 ± 2
MIM-Vertical, PD	DIST	0 ± 0.3	0.02 ± 0.4	0 ± 0.5
	NEAR	0.1 ± 0.7	0.02 ± 0.4	0 ± 0.5
MEM, D		0.3 ± 0.2	0.3 ± 0.2	0.4 ± 0.2
AC/A		4.5 ± 1	5.8 ± 0.6	5.4 ± 0.6

AC/A: accommodative convergence/accommodation ratio, CPM: cycles per minute, D: dioptres, MEM: monocular estimate method, MIM: muscle imbalance measure, NFV: negative fusional vergence, NPC-AT: near point of convergence with accommodative target, NPC-PLR: near point of convergence with penlight and red filter, PD: prism dioptres, PFV: positive fusional vergence

Table 4. Mean values of binocular vision parameters in convergence insufficiency (CI) and accommodative infacility (AIF) subjects

	NSABV	Normal BV	Total
Symptomatic	225	15	240
Asymptomatic	58	622	680
Total	283	637	920

Table 5. Number of children with symptomatic versus asymptomatic non-strabismic anomalies of binocular vision

ocular disease in children between six and 18 years of age,[3] with convergence insufficiency being the most prevalent of all types of non-strabismic anomalies of binocular vision.[1,4,5]

Convergence insufficiency was the most prevalent non-strabismic anomaly of binocular vision (16.5 and 17.6 per cent in the urban and rural arms, respectively) in the BAND study. Similar to our study results, convergence insufficiency has been reported to be the most common non-strabismic anomaly of binocular vision in previous reports[1,4–7] but there is a wide range of prevalences between 2.25 to 33 per cent[1–8,20] in other studies and this difference could possibly be attributed to the diagnostic criteria used. The prevalence of other types of non-strabismic anomalies of binocular vision in Indians is not known to the best of our knowledge.

Recent studies[1,4] in other ethnic groups that use a combination of parameters, rather than a single parameter (for example, near point of convergence) report prevalence similar to our study. We adopted the standard criteria suggested by Scheiman and colleagues[15] to diagnose non-strabismic anomalies of binocular vision and instead of using Morgan's expected values,[20] we used expected values derived from the normative data from our community.[11]

We found a potential age effect with the prevalence of non-strabismic anomalies of binocular vision increasing from 25.1 per cent in the seven to 12 years age group to 36.2 per cent in the 13 to 17 years age group. This trend may be related to the increased near visual demands in older children. In an adult population above 19 years of age, one in six adults was diagnosed with convergence insufficiency[21] and a significant increase in exophoria of seven prism dioptres (PD) was seen by 20 years in one-fourth of the sample after the initial diagnosis. Also, a significant association between reading and non-strabismic anomalies of binocular vision has been reported in the literature.[22,23] Thus, it becomes important to understand the impact of non-strabismic anomalies of binocular vision on reading and academic performance and these data are analysed separately as part of the BAND project.

Convergence insufficiency (14.6 and 19.6 per cent in the seven to 12 and 13 to 17 years age groups), followed by accommodative infacility (9.3 and 11.1 per cent in the seven to 12 and 13 to 17 years age groups) was the most prevalent non-strabismic anomalies of binocular vision. The prevalence of the remaining subtypes was less than two per cent. Using the diagnostic criteria and cut-off points proposed by Scheiman and colleagues,[17] the prevalence estimates for convergence insufficiency and accommodative infacility are reduced to six per cent each in the current sample. This suggests that an indigenous cut-off is more appropriate to detect symptomatic non-strabismic anomalies of binocular vision in the Indian population. Another potential difference for this prevalence variability is the cut-off for phoria that we used in our study. We observed in our sample, that a receded near point of convergence and/or a reduced near positive fusional vergence was present even when the distance and near phoria difference did not exceed 4 PD as per the standard CITT protocol.[16] The upper limit of the 95 per cent CI for the mean difference between the distance and near phoria was two PD in the normative data and so we applied this criterion to the classification of convergence insufficiency, although these values are liberal and overlap with test-retest variability range. This is one reason to recommend that a group of criteria be applied to reach a diagnosis rather than using a single parameter.

It is interesting to note that the prevalence of accommodative insufficiency is 0.2 per cent in our population, in contrast to the higher prevalence reported in the existing literature.[1,4,10,18] One of the main reasons for this finding may be the indigenous cut-off for amplitude of accommodation used in our population. If the cut-off had been based on conventional Hofstetter's minimum expected amplitude of accommodation,[24,25] 77 (eight per cent) out of the overall 920 would have been diagnosed with accommodative insufficiency. We also did not find children who reported symptoms of near visual blur, a finding consistent with diagnosis of accommodative insufficiency. Similar findings of differences in amplitude of accommodation from Hofstetter's data have been reported earlier in the adult population in India[26] and also by Sterner, Gellerstedt and Sjöström.[10] It is also important to note that the mean amplitudes of accommodation in convergence insufficiency were statistically significantly different from the normal binocular vision group, although these differences were clinically insignificant.

In this study, a large proportion of children (20.5 per cent) were asymptomatic in the presence of abnormal parameters of binocular vision. The literature suggests that symptomatic individuals are more likely to fail Sheard's criterion.[27,28] In our population, in the asymptomatic non-strabismic anomalies of binocular vision group, 12.1 per cent failed Sheard's criterion, whereas in the symptomatic group, 13.8 per cent failed Sheard's criterion. These proportions were not statistically significant (Z-test; $p > 0.05$), thus revealing no significant association between Sheard's criterion and symptoms. Increased variability and reduced reliability associated with vergence testing could be reasons for this finding.[17]

We also re-applied the standard clinical criteria for diagnosis proposed by Scheiman and Wick[17] to the asymptomatic non-strabismic anomalies of binocular vision group. When these criteria were applied, the proportion of asymptomatic non-strabismic anomalies of binocular vision reduced to 14.8 from 20.5 per cent. Out of the 58 children, 37 had convergence insufficiency, 15 had accommodative infacility, two had convergence excess and four had fusional vergence dysfunction. This suggests that the criteria for diagnosis do not significantly change the proportion of asymptomatic non-strabismic anomalies of binocular vision. We have not done any intervention for the asymptomatic non-strabismic anomalies of binocular vision in this study, although we educated the children about the potential visual symptoms that could develop over a period of time. Also, there is no clarity on why these children are asymptomatic, although reduced visual demands, cognition and awareness could be hypothesised as possible reasons. Studies have shown an association between symptomatic convergence insufficiency and academic performance[12] and vision therapy for convergence insufficiency significantly improved academic performance.[13] These results could be extrapolated to the overall non-strabismic anomalies of binocular vision and thus, demand the need for screening for non-strabismic anomalies of binocular vision among children, so that appropriate intervention can be planned.

The higher prevalence of non-strabismic anomalies of binocular vision reported in our study has implications for the public health strategies adopted with respect to eye care among Indian school children. Vision screening protocol designed only to screen for refractive errors and ocular pathology will miss a significant number of important non-strabismic anomalies of binocular vision.

CONCLUSION

Non-strabismic anomalies of binocular vision are highly prevalent among school children in both rural and urban areas. Convergence insufficiency is the most common non-strabismic anomaly of binocular vision followed by accommodative infacility. Screening for anomalies of binocular vision should be part of the vision screening protocol and appropriate intervention should be planned for non-strabismic anomalies of binocular vision.

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APPENDIX I: DIAGNOSTIC CRITERIA FOR NON-STRABISMIC ANOMALIES OF BINOCULAR VISION

The generic criteria for the diagnosis are adapted from Scheiman and Wick[15] and the specific cut-off has been derived from the normative data from phase one of the current study.[11]

1. Convergence insufficiency

Symptoms:

Associated with reading or other near tasks and generally worse at end of day. The most common symptoms include asthenopia and headaches, intermittent diplopia.

Signs:

1. Greater exophoria for near than distance by more than 2 prism dioptres (PD).
2. Receded near point of convergence (NPC) break with accommodative target greater than 6 cm.
3. Receded NPC break with penlight and red filter greater than 12 cm.
4. Reduced positive fusional vergence (PFV) break less than 15 PD.
5. Difficulty clearing +2.00 DS with binocular accommodative facility (BAF) less then 8 cycles per minute (CPM).

For diagnosis: Two out of the first four criteria are mandatory.

2. Divergence insufficiency

Symptoms:

Associated with distance viewing. The most common include intermittent diplopia for distance, headache and eyestrain.

Signs:

1. Esophoria greater for distance than near by more than 3 PD.
2. Reduced negative fusional vergence (NFV) break less than 6 PD for distance.
3. Difficulty clearing −2.00 DS with binocular accommodative facility less than 8 CPM.

For diagnosis: Criterion 1 is mandatory with a minimum of one criterion from 2 and 3.

3. Convergence excess

Symptoms:

Associated with reading or other near tasks and generally worse at end of day.

The most common include asthenopia, headaches and intermittent diplopia.

Signs:

1. Esophoria greater at near than distance by 3 PD.
2. Reduced NFV break less than 10 PD at near.
3. Difficulty with binocular accommodative facility with −2.00 DS less than 8 CPM.
4. High monocular estimate method (MEM) lag of accommodation greater than +1.25 DS.

For diagnosis: Criterion 1 is mandatory with a minimum of one criterion from 2, 3 or 4.

4. Divergence excess

Symptoms:

Associated with distance viewing than near. The most common include intermittent diplopia for distance, headache and eyestrain.

Signs:

1. Intermittent to constant exo deviation for distance greater than near of more than 4 PD.
2. Low positive fusional vergence break less than 10 PD for distance.
3. Difficulty clearing +2.00 DS with BAF less than 8 CPM.

For diagnosis: Criterion 1 is mandatory with a minimum of one criterion from 2 and 3.

5. Fusional vergence dysfunction

Symptoms:

Associated with reading or other near tasks and generally worse at end of day. The most common symptoms include asthenopia and headaches, blurred vision and difficulty concentrating on near visual tasks.

Signs:

1. Reduced NFV less than 10 PD and PFV less than 15 PD break at near and reduced NFV less than 6 PD and PFV less than 10 PD break at distance.
2. Difficulty with both ± 2.00 DS in BAF – less than 8 CPM.
3. Normal monocular accommodative facility (MAF) more than 8 CPM.

For diagnosis: One out of the first two criteria is mandatory; criterion 3 is mandatory.

6. Basic esophoria

Symptoms:

Associated with reading or other near tasks and with distant activities. The most common near point complaints include eyestrain, headaches and blurred vision. Common symptoms associated with distance include blurred vision and diplopia, when watching television and in classroom.

Signs:

1. Equal magnitude of esophoria at distance and near.
2. Reduced NFV break less than 6 PD at distance and less than 10 PD at near.
3. Difficulty with BAF with −2.00 DS less than 8 CPM.

For diagnosis: Criteria 1 is mandatory with one out of the next two criteria.

7. Basic exophoria

Symptoms:

Associated with reading or other near tasks and with near and distant activities. The most common near point complaints include eyestrain, headaches and blurred vision.

Signs:

1. Equal amount of exophoria at distance and near.
2. Receded NPC break less than 6 cm with accommodative target.
3. Reduced PFV break less than 10 PD for distance and less than 15 PD at near.
4. Difficulty clearing +2.00 DS with BAF less than 8 CPM.

For diagnosis: Criterion 1 is mandatory with two out of the next three criteria.

8. Accommodative insufficiency

Symptoms:

Blurred near vision, discomfort and strain associated with near tasks, fatigue associated with near point tasks, difficulty with attention and concentration when reading.

Signs:

1. Blur at near point testing at Harmon's distance.
2. Reduced amplitude of accommodation by 2.00 D or more from the average amplitude of accommodation derived from the normative equation 16 – 0.3 (age).
3. Difficulty with MAF – less than 7 CPM and BAF less than 8 CPM with −2.00 DS.
4. High monocular estimate method lag of accommodation (more than +1.25 DS).

For diagnosis: Criteria 1 and 2 are mandatory with one out of the next two criteria.

9. Accommodative excess

Symptoms:

Blurred distance vision worse after reading or other close work and often worse toward the end of the day, headaches and eyestrain after short periods of reading, difficulty focusing from far to near, sensitivity to light.

Signs:

1. Low monocular estimate method (less than or equal to plano) (lead of accommodation).
2. Esophoria for near more than 3 PD.
3. Variable visual acuity findings.
4. Variable static retinoscopic and subjective refraction.

For diagnosis: Criteria 1 and 2 are mandatory with one out of the next two criteria.

10. Accommodative infacility

Symptoms:

Blurred near vision, blurred distance vision after near visual tasks and vice versa, delayed focusing of objects, discomfort and strain associated with near tasks, fatigue associated with near tasks, difficulty with attention and concentration when reading.

Signs:

1. Difficulty with MAF less than 7 CPM and/or BAF less than 8 CPM with both ±2.00 DS in the presence of NFV findings.
2. Normal amplitude of accommodation.
3. Normal fusional vergence amplitudes.

For diagnosis: All three criteria are mandatory.