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Symptomatic accommodative disorders and asthenopia: Prevalence and association in Ghanaian children

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Background: There is a scarcity of data on asthenopia and accommodative disorders in children in Ghana as optometrists sometimes fail to carry out comprehensive assessments because of the lack of appropriate instruments.

Aim: To establish the prevalence of asthenopic symptoms and symptomatic accommodative disorders among Junior High School children in Cape Coast metropolis (in their habitual vision state) and to investigate if there are any associations between asthenopic symptoms and the disorders.

Method: A prospective cross-sectional school-based study using a multistage sample of 627 participants aged 12–17 years from Junior High Schools in Cape Coast metropolis, Ghana, was conducted. Participants completed a reliable asthenopic symptoms questionnaire (Cronbach's $\alpha = 0.866$), and 220 participants who expressed two or more severe or very severe symptoms were selected for comprehensive accommodative system assessment over their habitual vision state.

Results: The prevalence of symptoms of asthenopia (two or more severe or very severe) and symptomatic accommodative disorders were 35.1% and 17.4% respectively. For specific symptomatic accommodative disorders, the prevalence was as follows: 7.7% accommodative insufficiency, 4.5% accommodative infacility, 1.4% accommodative excess and 3.8% accommodative fatigue. There were significant associations between some specific accommodative disorders and some specific asthenopic symptoms even though these asthenopic symptoms overlapped in other accommodative disorders.

Conclusion: Specific asthenopic symptoms do not discriminate between the presences of specific types of accommodative disorders. A comprehensive accommodative system assessment with appropriate instruments is relevant to the diagnosis and management of accommodative disorders to relieve asthenopic symptoms.

Introduction

Many people of all age groups and genders unpleasantly experience binocular vision dysfunctions.[1] A study[2] showed that accommodative and binocular vision disorders in comparison with ocular disease are 9.7 times more prevalent in children aged from 6 months to 5 years of age and 8.5 times more prevalent in children aged 6–18 years. Although these are alarming statistics, there is no connection between these highly frequent binocular vision problems in the general population and the patients with binocular vision disorders examined in optometric centres.[1,2] Non-strabismic binocular vision disorders are classified as accommodative disorders and vergence disorders.[3] Accommodative disorders are characterised by inadequate accommodative accuracy and sustainability; inadequate amplitude, flexibility and facility; and are non-refractive and non-ageing neuromuscular abnormalities of the visual apparatus.[4] The specific accommodative disorders include accommodative insufficiency, accommodative excess, accommodative fatigue (ill-sustained accommodation) and accommodative infacility (inertia of accommodation), and all these are purely functional in origin.[5]

A presenting symptom of patients with accommodative disorder is asthenopia.[6] Accommodative disorders can thus have adverse effects on children's academic performance,[7,8,9] especially in the levels where the print size decreases and reading demand increases.[10,11,12] The child may be inattentive and easily distracted and may not be able to complete reading or homework assignments comfortably.[4,13] Children with general reading difficulties, learning disability and

dyslexia can have accommodative problems.[14,15] The demand on the accommodative system, coupled with its effects on activities of daily living, is of concern, especially for the high school child.

Recent studies estimate that about 20% of cases reporting to optometric clinics are one of binocular vision anomalies[16]; however, most centres in Ghana do not comprehensively investigate the binocular system because of a lack of instruments.[17] Few studies[17,18,19] have been conducted on accommodation in Ghana; however, these studies did not comprehensively investigate for specific accommodative disorders. The only study[19] which investigated for two of the accommodative disorders, namely accommodative insufficiency and accommodative infacility, used only amplitude of accommodation and +2/−2-D flippers as diagnostic signs for the two conditions, respectively.

In this study, a comprehensive battery of accommodative tests were conducted on Junior High School (JHS) children in Cape Coast, Ghana to investigate for the clinical signs of all the specific accommodative disorders over participant's habitual vision state. The aim was to establish the prevalence of asthenopic symptoms and symptomatic accommodative disorders (SAD) among the participants and to investigate any associations between asthenopic symptoms and specific SAD in participant's habitual vision state (to simulate the usual condition under which participants functioned)

Research methods and design

A prospective, cross-sectional, school-based study was conducted in JHS in the Cape Coast metropolis, Ghana. The study population involved 9153 JHS students,[20] and those within the age range of 12–17 years were included in the study. Students with visual acuity worse than 0.2 LogMAR, strabismus, blind eyes or external or internal eye diseases were excluded from the study.

The sample technique was multistage, and the minimum sample size was calculated to be 317. The 73 JHS in the metropolis were grouped into six clusters, and simple random sampling was used to select two schools from each of the six clusters. Fifty-three students were randomly selected from each of the 12 selected schools. In all, 636 students were sampled and 9 were excluded (strabismus [1], ocular media opacities [2] and visual acuity worse than 0.2 LogMAR [6]); hence, 627 students participated in the study.

Data collection

A reliable 20-point asthenopic symptom questionnaire with good internal consistency (Cronbach's $\alpha = 0.866$) and examination forms comprising optometric (clinically accepted) routine test procedures were used to collect data. All study participants ($n = 627$) completed the questionnaire, and a total of 220 participants with two or more symptoms (severe or very severe) were considered symptomatic[21] and selected for complete accommodative system examination. The examination procedures included amplitude of accommodation using the push-up to blur method, accommodative lag using the monocular estimation method, binocular accommodative facility and monocular accommodative facility using +2/−2-D flippers, positive and negative relative accommodation, gradient AC/A ratio and positive and negative fusional vergence measurement at distance and near using Risley prisms with the manual phoropter (Topcon VT-10).

Accommodative testing was performed over the participant's habitual spectacle prescriptions[22] if they wore one or over no correction if they did not use spectacles. Spectacle prescriptions were checked and confirmed using a manual lensmeter (Briot LM-25) The results of each accommodative test were compared with clinical normative values (expected values for accommodative and vergence testing).[3] More than 80% of the clinical diagnostic signs (test results that deviated from the normal values) for each of the specific accommodative disorders were grouped together as syndromes to diagnose specific accommodative disorders using criteria by Scheiman and Wick.[5] SAD was diagnosed if a participant expressed two or more asthenopic symptoms[21] (severe or very severe) on the reliable questionnaire and had more than 80% of the clinical diagnostic signs of specific accommodative disorders using criteria by Scheiman and Wick[5] during complete accommodative assessment.

Data analysis

The data collected were analysed using the IBM SPSS Statistics (version 21). Descriptive statistics were used to analyse all the quantitative data. Distributions of variables were presented in text, tables and bar charts. Estimates of prevalence were presented in proportions with their corresponding 95% confidence intervals (CIs). Pearson's chi-square was used to investigate possible associations between certain parameters and outcome variables. Multivariate binary logistic regression was also used to test for significant associations holding other confounding variables constant. An independent-sample *t*-test was used to test for a significant difference in age between males and females. Pearson's correlation tests were used to analyse correlations between amplitudes of accommodation for right and left eyes and lag of accommodation for right and left eyes. A *p*-value of less than or equal to 0.05 was considered statistically significant.

Ethical considerations

Conforming to the Declaration of Helsinki regarding research with human subjects, this study was approved by the Biomedical Research Ethics Committee (University of KwaZulu-Natal) and by the Ghana Health Service Ethics Review Committee. Institutional permission was sought and approved by the Cape Coast Metro Education Authority in Ghana and head teachers of the various JHS in Cape Coast. Parents or guardians of participants provided signed informed consent and JHS children gave assent to participate in the study.

Results

Study participants (n = 627) comprised 296 male and 331 female participants who were between the ages of 12 and 17 years (mean age: 14.05 ± 1.49 years). There was no significant difference in age between male and female participants (t = 0.982, p = 0.160). Of the 627 participants, 220 participants comprising 82 male and 138 female students expressed two or more severe to very severe asthenopic symptoms and were examined for signs of accommodative disorders. The ages of these participants were normally distributed, and there was no significant difference in age between male and female participants (t = 0.084, p = 0.218). There was a significant positive correlation between amplitude of accommodation for right and left eyes (R = 0.924, p = 0.00). There was a significant positive correlation between lag of accommodation for right and left eyes (R = 0.990, p = 0.00). Of the participants selected for accommodative testing, 28 (12.7%) habitually used spectacles.

The prevalence of asthenopic symptoms (two or more severe or very severe) among the JHS children in the Cape Coast metropolis was 35.1% (95% CI: 31.45% – 38.90%). Among male participants, the prevalence was 13.1% (95% CI: 10.66% – 15.94%) and among female participants the prevalence was 22.0% (95% CI: 18.94% – 25.42%). Each of the specific asthenopic symptoms was more frequent in female than male participants (Figure 1). The most frequently reported asthenopic symptom among participants with severe or very severe asthenopic symptom was headaches associated with near work (61.8%) and the least reported symptom (20.0%) was eyestrain (squinting) associated with near work (Table 1). Among participants diagnosed with accommodative disorders, the most reported asthenopic symptom was headaches associated with near work (63.3%) and the least (22.0%) was eyestrain (squinting) associated with near work (Figure 2).

The prevalence of SAD among JHS children in the Cape Coast metropolis was 17.4% (95% CI: 14.62% – 20.55%). Among the 220 participants who reported severe or very severe asthenopic symptoms, the frequency of SAD was 49.5% (95% CI: 43.00% – 56.10%). For the specific SAD, the prevalence of accommodative insufficiency among JHS children was 7.7% and 21.8% among participants with severe and very severe asthenopic symptoms, respectively (Table 2). Accommodative insufficiency was the most frequent SAD among participants with specific asthenopic symptoms (Figure 3).

There was a significant association between gender and the symptoms of headaches associated with near work (χ^2 = 9.414, p = 0.002) and watery eyes (tearing) with near work (χ^2 = 4.854, p = 0.028) in a univariate analysis. Male participants had greater odds of experiencing symptoms of headaches associated with near work (odds ratio [OR] = 2.180, 95% CI: 1.219–3.897; p = 0.009) compared with female participants (OR = 0.459, 95% CI: 0.257–0.820; p = 0.009). Male participants had greater odds of experiencing symptoms of watery eyes (tearing) with near work

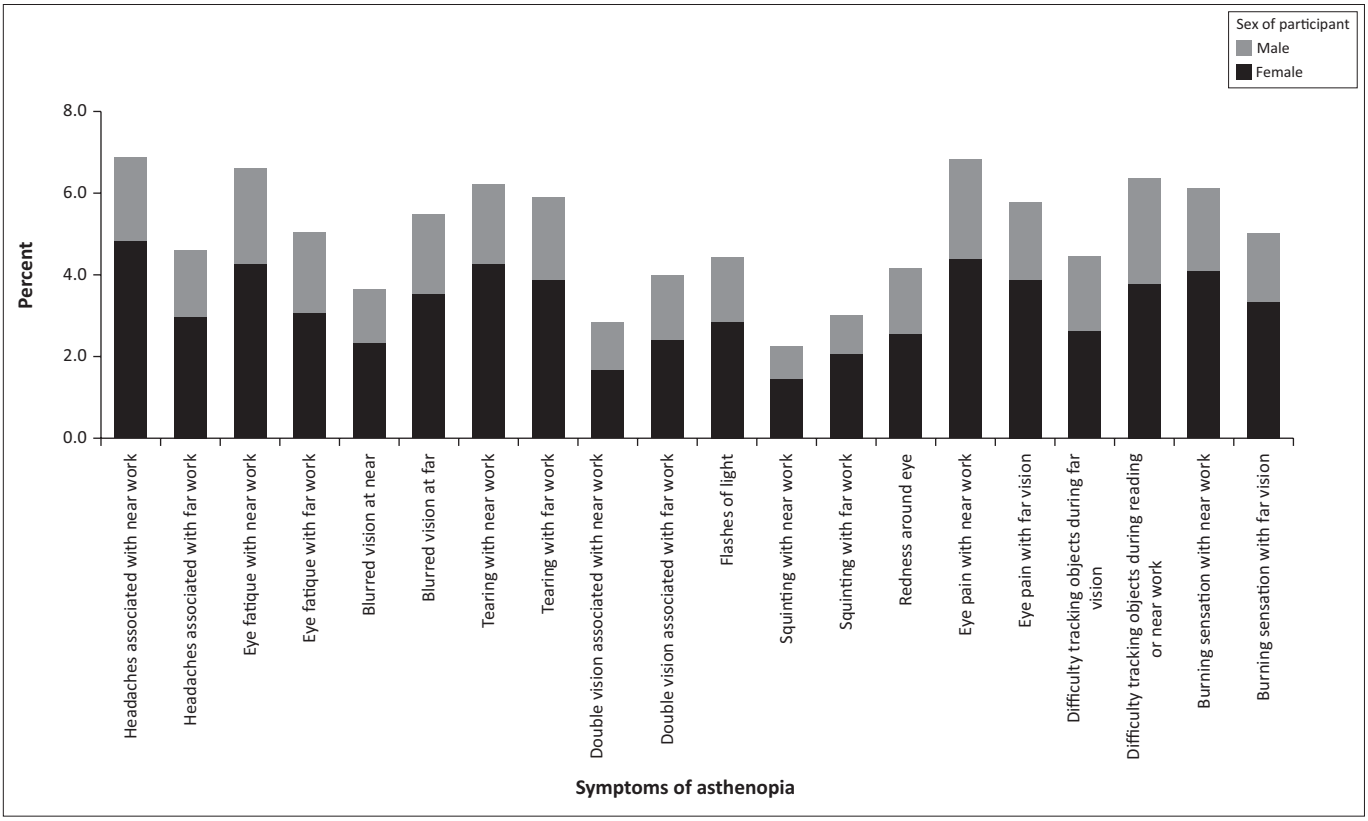

FIGURE 1: Gender distribution of asthenopic symptoms.

TABLE 1: Distribution and prevalence of specific asthenopic symptoms among participants with severe or very severe asthenopic symptom.

Symptom	Frequency	Prevalence	
		%	95% Confidence interval
Headaches associated with near work	136	61.8	55.25–67.98
Headaches associated with far vision	91	41.4	35.06–47.97
Eye fatigue associated with near work	131	59.5	52.95–65.81
Eye fatigue associated with far vision	100	45.5	39.01–52.06
Blurred vision at near	72	32.7	26.87–39.18
Blurred vision at far	108	49.1	42.56–55.66
Watery eyes (tearing) with near work	123	55.9	49.30–62.31
Watery eyes (tearing) with far vision	117	53.2	46.59–59.66
Double vision associated with near work	56	25.5	20.10–31.60
Double vision associated with far work	78	35.5	29.40–41.98
Flashes of light	88	40.0	33.70–46.59
Eye strain (squinting) associated with near work	44	20.0	15.20–25.78
Eye strain (squinting) associated with far vision	59	26.8	21.40–33.03
Redness around eye	82	37.3	31.15–43.83
Eye pain with near work	135	61.4	54.70–67.55
Eye pain with far vision	114	51.8	45.20–58.33
Difficulty tracking objects during near work	126	57.3	50.60–63.63
Difficulty tracking objects during far vision	88	40.0	33.70–46.59
Burning sensation with near work	121	55.0	48.40–61.43
Burning sensation with far vision	99	45.0	38.57–51.60

TABLE 2: Prevalence of specific accommodative disorders among participants.

Accommodative disorders	Frequency	Participants with asthenopia: Prevalence		Junior high school students in Cape Coast metropolis: Prevalence	
		%	Within 95% Confidence interval	%	Within 95% Confidence interval
Accommodative Insufficiency	48	21.8	16.87–27.73	7.7	5.82–10.00
Accommodative infacility	28	12.7	8.95–17.78	4.5	3.11–6.38
Accommodative excess	9	4.1	2.17–7.59	1.4	0.76–2.71
Accommodative fatigue	24	10.9	7.44–15.72	3.8	2.59–5.63

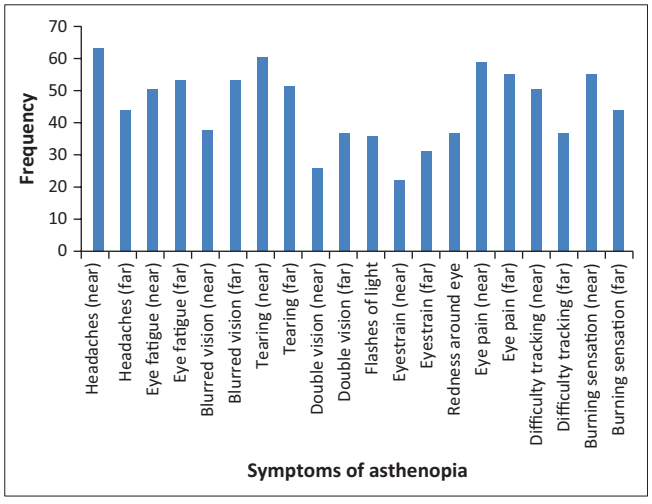

FIGURE 2: Distribution of prevalence of asthenopic symptoms among participants with accommodative disorders.

(OR = 1.771, 95% CI: 1.004–3.125; $p = 0.048$) compared with female participants (OR = 0.565, 95% CI: 0.320–0.996; $p = 0.048$). There was no significant association between SAD and gender in the univariate analysis ($\chi^2 = 1.665$, $p = 0.197$). There was a significant association between SAD and spectacle wear in the univariate analysis ($\chi^2 = 8.316$, $p = 0.004$). Participants who wore spectacles had greater odds of having accommodative disorders (OR = 0.286, 95% CI: 0.116–0.705; $p = 0.007$) compared with vergence disorders. For specific accommodative disorders, there was a significant association between spectacle wear and accommodative insufficiency in the univariate analysis ($\chi^2 = 5.739$, $p = 0.017$). Participants who wore spectacles had greater odds of experiencing accommodative insufficiency (OR = 0.374, 95% CI: 0.161–0.867; $p = 0.022$) compared with other specific accommodative disorders.

There was a significant association between spectacle wear and the symptoms of headaches associated with far work ($\chi^2 = 4.953$, $p = 0.026$), eye fatigue associated with far work ($\chi^2 = 6.494$, $p = 0.011$) and difficulty tracking objects during far vision ($\chi^2 = 3.929$, $p = 0.047$) in the univariate analysis. Participants who wore spectacles had greater odds of experiencing symptoms of headaches associated with far work (OR = 0.425, 95% CI: 0.187–0.964; $p = 0.04$), eye fatigue associated with far work (OR = 0.380, 95% CI: 0.161–0.894; $p = 0.027$) and difficulty tracking objects during far vision (OR = 0.423, 95% CI: 0.187–0.955; $p = 0.038$) compared with other symptoms.

Univariate analysis revealed some significant associations between SAD and specific asthenopic symptoms (Table 3). Participants diagnosed with SAD had greater odds of experiencing symptoms of eye fatigue associated with near work (OR = 1.993, 95% CI: 1.128–3.521; $p = 0.017$) and symptoms of eye fatigue associated with far work (OR = 0.535, 95% CI: 0.304–0.944; $p = 0.031$) compared with other symptoms. Participants diagnosed with accommodative

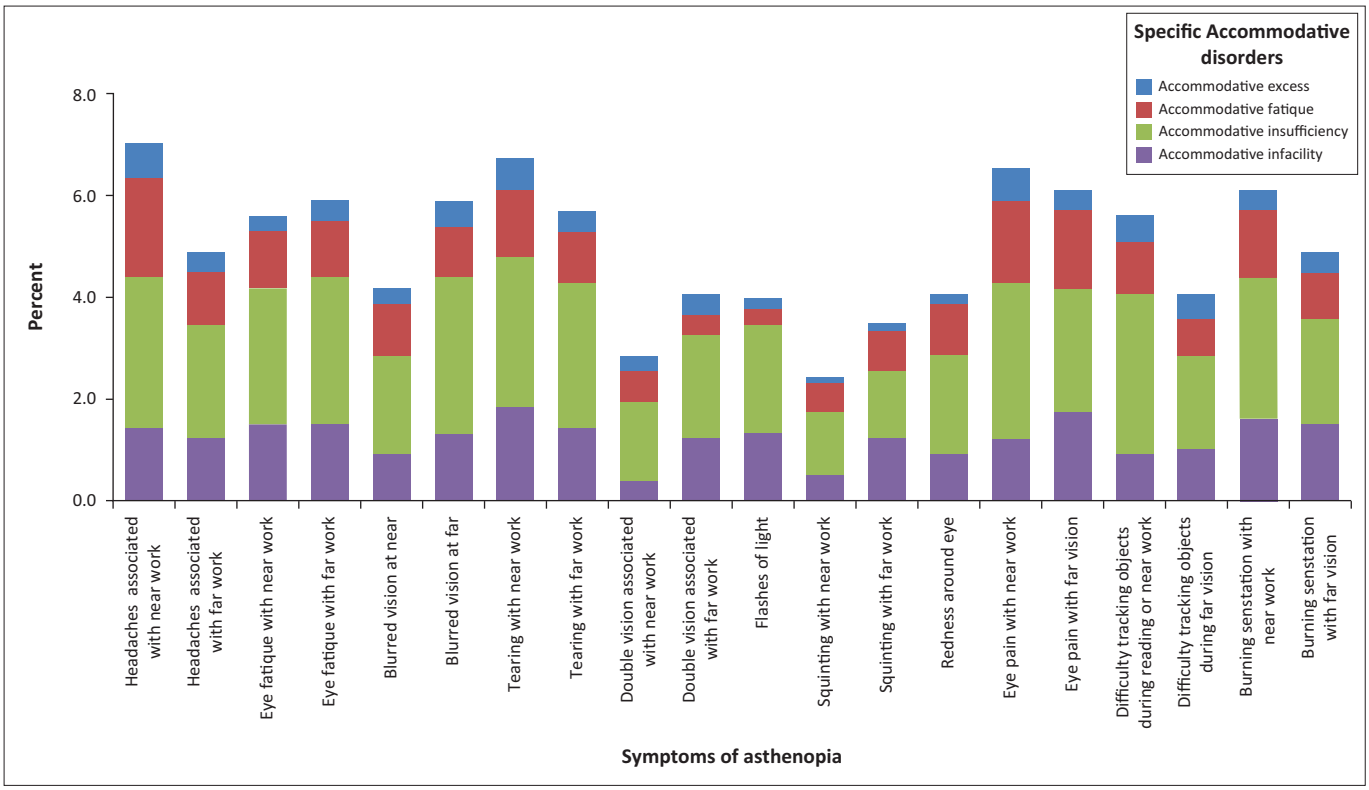

FIGURE 3: Distribution of accommodative disorders among specific asthenopic symptoms.

TABLE 3: Association between accommodative disorders in general and asthenopic symptoms in the univariate analysis.

Asthenopic symptom	Accommodative disorder	
	χ^2	*p*-value
Headaches associated with near work	0.202	0.653
Headaches associated with far vision	0.636	0.425
Eye fatigue associated with near work	7.405	**0.007**
Eye fatigue associated with far work	5.242	**0.022**
Blurred vision at near	2.344	0.126
Blurred vision at far	1.467	0.226
Watery eye (tearing) with near work	1.888	0.169
Watery eye (tearing) with far vision	0.283	0.595
Double vision associated with near work	0.006	0.937
Double vision associated with far vision	0.146	0.703
Flashes of light	1.603	0.205
Eyestrain with near work	0.550	0.458
Eye strain with far vision	2.106	0.147
Redness around eye	0.310	0.861
Eye pain with near work	0.639	0.424
Eye pain with far vision	0.901	0.342
Difficulty tracking objects during reading or near work	4.099	**0.043**
Difficulty tracking objects during far vision	0.982	0.322
Burning sensation with near work	0.000	0.989
Burning sensation with far vision	0.810	0.776

Bold values indicate significant associations.

infacility had greater odds of experiencing symptoms of eye pain with near work (OR = 2.498, 95% CI: 1.081–5.768; $p = 0.032$) and difficulty tracking objects during near work (OR = 3.215, 95% CI: 1.350–7.656; $p = 0.008$) compared with the other symptoms. Participants diagnosed with accommodative fatigue had greater odds of experiencing symptoms of flashes of light (OR = 4.913, 95% CI: 1.393–17.336; $p = 0.013$) compared with other symptoms.

Discussion

The prevalence of asthenopic symptoms in the present study is almost comparable with one study on children[23] even though in that study symptoms were not graded and asthenopia was defined as the presence of one or more of the symptoms. The result is lower compared with other studies[21,24,25]; two of these studies[24,25] with higher prevalence defined asthenopia as one or more of the symptoms identified and did not grade symptoms as compared with our study. One of these studies was conducted on college students[25] and another on individuals during and after computer use.[21] Generally, there is a higher demand on the visual system from academic work by college students[26] and during computer use[27] as compared with JHS children, which may also account for the difference. Another study on school-aged children 6–16 years old[28] reported a lower prevalence of asthenopia compared with the results in this study. The greater demand on the near-vision system in the high school stage[10] may explain the higher prevalence of asthenopic symptoms among the population in the present study compared with the younger age population in the other study.[10]

Prevalence for specific asthenopic symptoms in three studies[24,26,29] ranged from 1% to 35%, 3.1% to 13.8%, and 4.6% to 9.9%, respectively, which were lower compared with the prevalence range of 20% – 61.4% for specific asthenopic symptoms in the present study. However, it is difficult to compare this study with these other three studies[24,26,29] because the present study used a 20-point symptom questionnaire while these other studies analysed only symptoms reported by patients.

The prevalence of asthenopic symptoms in the present study was higher among the female participants than the male participants, which is comparable with some studies.[9,21,30,31,32] Two[9,32] of these studies were conducted on similar school-aged population of African children. Also, visual symptom scores were found to be higher among female participants than male participants in a Japanese study by Shima et al.[33] But it involved adult female participants working on video display terminals. In our study, all the 20 specific asthenopic symptoms were found to be more prevalent among female participants than male participants. In a similar study,[9] the prevalence was higher for female participants than male participants who experienced the symptoms always. The other studies reviewed[9,21,30,31,33] did not analyse the prevalence of specific asthenopic symptoms in relation to gender. Symptoms such as headaches have been attributed to drops in the levels of the female hormone oestrogen and progesterone during the start of a female's menstrual cycle.[34] Even though in the present study, asthenopic symptoms were assessed with emphasis on use of the eyes for near work and far work, female participants may have associated their headaches to visual rather than hormonal changes. In contrast to this study, however, Han et al. determined a higher prevalence of asthenopia among male participants than female participants.[25]

Comparable with our study, a cross-sectional practice-based retrospective study of 1109 school-aged African children also found headaches to be the most common asthenopic symptom and diplopia as least prevalent.[32] However, our study specified the headaches for near and far in contrast to the above study,[32] which grouped the headaches into types depending on location. In two studies,[23,35] the most prevalent asthenopic symptom among participants with binocular vision disorder was headaches associated with near work, which is consistent with the results of the present study. In another study,[36] one of the most common associated symptoms was headaches and the least reported ocular symptom was diplopia; however, it involved participants working on video display terminals only. Comparable with this study, three studies[24,26,29] determined the least prevalent asthenopic symptom among participants with non-strabismic binocular vision disorders to be intermittent diplopia and diplopia. It was found that accommodative disorders presented more with near-vision complaints than far vision complaints. This is consistent with results in another study.[35] With advancement in near-vision devices such as computers and mobile phone technology today, the demands placed on the visual system for near work are greater compared with the demands at far.[37] However, participants also complained about far vision problems; this is consistent with some studies,[23,26,35,38,39,40] which reported about asthenopic symptoms at far among participants with binocular vision disorders.

Our study is consistent with the study by Richman and Laudon[22] who also conducted binocular testing over participants habitual vision state (even though the latter study was conducted on university students); all other studies reviewed[9,24,26,29,41] investigated for accommodative disorders over best-corrected refraction results. Diagnoses of SAD required investigating for all the clinical signs of specific accommodative disorders using a widely accepted and more recent classification system[5] and a systematic method of analysis. These battery of tests were comparable with other studies[24,26,29,41]; however, these reviewed studies conducted the tests over routine refractive correction. This may serve as basis for discrepancies in results between the present study and other reviewed studies. Some of these studies reviewed[24,26,29] used lesser numbers of diagnostic signs as compared with our study, which used more than 80% of the clinical signs of specific accommodative disorders. Rarely will one detect all the components of diagnosis of a binocular vision condition on a single patient.[1] As some authors[26,41] indicate the prevalence tends to reduce as the number of diagnostic signs increase, a greater number of clinical signs were used in this study compared with other studies[24,26,29] so that the prevalence were not exaggerated. In addition to the clinical signs, all participants diagnosed with accommodative disorders in our study expressed asthenopic symptoms, which is comparable with some studies.[26,29,41]

The prevalence of SAD in our study was higher compared with studies on accommodative disorders conducted on school children elsewhere[8,9]; however, these other studies did not consider the presence of asthenopic symptoms in defining accommodative disorder. Among symptomatic participants, the prevalence of SAD was lower compared with another study on school-aged population elsewhere.[29] However, the prevalence was higher in our study compared with other reviewed studies[24,26,41] most of which used different study populations and symptoms were not graded compared with our study.

Consistent with our study, accommodative insufficiency was the most prevalent accommodative disorder in some studies[24,29,42,43] and accommodative infacility was the second most prevalent in one study.[42] However, differences in study designs and populations exist between these other studies[24,29,42,43] and our study. However, In contrast to our study, one study[9] determined the prevalence of accommodative insufficiency to be the same as accommodative infacility among similar black JHS children. Because of the commonalities of accommodative insufficiencies among populations, several studies have been done on it compared with other disorders[35]; again because of the many different studies, specific questionnaires have been developed to investigate specifically accommodative insufficiency.[40,44,45] Participants diagnosed with accommodative insufficiency expressed each of the asthenopic symptoms greatly compared with other forms of accommodative disorders. This result is in agreement with results reported in another study.[35] However, in contrast to this study, accommodative infacility was the least prevalent of the accommodative disorders in a study[24] and accommodative excess was the most prevalent accommodative disorder in another study.[41] These differences may be attributed to the difference in study design, population and location.

Even though the prevalence of asthenopia was higher among female participants than male participants, the male gender was significantly more likely to experience the symptoms of headaches associated with near work and the symptom of watery eyes (tearing) with near work as compared with the female participants. One study[30] in comparison with our study found a significant association between asthenopia and gender. However, in contrast to this study, another study[23] determined no significant relationship between general symptoms and gender. Among other studies which compared asthenopia and gender, none determined statistically significant associations between gender and the specific symptoms involved.[9,21,23,25,44] However, another study[46] found that visual fatigue was associated with gender and was higher in female analysts than male analysts. Gender did not significantly predispose participants to specific accommodative disorders in our study. None of the studies reviewed[8,9,24,26,29,41] determined statistically significant associations between gender and SAD.

With the correct spectacles prescribed through comprehensive optometric investigation and with the prescription of specialised vision therapy if need be, spectacle wearers are less likely to complain of asthenopic symptoms relating to near or far work.[3] In our study, there were significant associations between spectacle wear and some specific symptoms; no known study has reported this finding. This suggests that perhaps comprehensive optometric assessments were not conducted to investigate all possible causes of asthenopia before the spectacles were prescribed and dispensed. There was a significant association between spectacle wear and SAD, specifically accommodative insufficiency. Asthenopic symptom complaints among spectacle wearers in our study may thus be because of the underlying uncorrected accommodative disorders.

In an attempt to investigate whether asthenopic symptoms are peculiar to general or specific accommodative disorders, our study sought to determine any significant associations between them and found some specific associations. Apart from one study,[9] none of the other studies reviewed[26,31,35,41] explored associations between the asthenopic symptoms and accommodative disorders. A pilot study[9] of a black high school population using a 20-point symptom questionnaire did not determine any statistically significant associations between this disorder and asthenopic symptoms. The difference in results between ours and their study[9] may be attributed to the fact that binocular vision assessment was performed over best-corrected refractive prescription in other study.[9] Best spectacle correction may have compensated for some accommodative disorders present thus relieving patients of the symptoms of asthenopia.[9]

In conclusion, even though this study revealed significant associations between some SAD and some asthenopic symptoms, it cannot be concluded that those specific asthenopic symptoms are specific to the specific SAD diagnosed. This is so because most of these specific symptoms overlap in other accommodative disorders, a result which is similar to a report.[35] Thus, this study complies with the results of two studies[29,35] that presenting complaints of specific asthenopic symptoms does not discriminate between the presence of specific types of SAD.

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Competing interests

We declare that we have no financial or personal relationship(s) that may have inappropriately influenced us in writing this article.

Authors' contributions

C.D-T. conceived the project, designed the study, acquired the data, analysed and interpreted the data, drafted the article, revised it for important intellectual content and approved the final copy for publication. N.E.K. was the project supervisor, revised the article for important intellectual content and approved the article for publication. U.N. was a co-supervisor of this project, revised this article for important intellectual content and approved this article for publication.

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