



Accommodative insufficiency as cause of asthenopia in computer-using students

Husnun Amalia*, Gusti G. Suardana**, and Widya Artini**

ABSTRACT

*Department of Ophthalmology,
Medical Faculty,
Trisakti University
**Department of
Ophthalmology,
Faculty of Medicine,
University of Indonesia

Correspondence

dr. Husnun Amalia, SpM
Department of Ophthalmology,
Medical Faculty,
Trisakti University
Jl. Kyai Tapa No.260 Grogol
Jakarta 11440
Phone: 021-5672731 ext.2614

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To date the use of computers is widely distributed throughout the world and the associated ocular complaints are found in 75-90% of the population of computer users. Symptoms frequently reported by computer users were eyestrain, tired eyes, irritation, redness, blurred vision, diplopia, burning of the eyes, and asthenopia (visual fatigue of the eyes). A cross-sectional study was conducted to determine the etiology of asthenopia in computer-using students. A questionnaire consisting of 15 items was used to assess symptoms experienced by the computer users. The ophthalmological examination comprised visual acuity, the Hirschberg test, near point accommodation, amplitude accommodation, near point convergence, the cover test, and the alternate cover test. A total of 99 computer science students, of whom 69.7% had asthenopia, participated in the study. The symptoms that were significantly associated with asthenopia were visual fatigue ($p=0.031$), heaviness in the eye ($p=0.002$), blurred vision ($p=0.001$), and headache at the temples or the back of the head ($p=0.000$). Refractive asthenopia was found in 95.7% of all asthenopia patients with accommodative insufficiency (AI), constituting the most frequent cause at 50.7%. The duration of computer use per day was not significantly associated with the prevalence of asthenopia ($p=0.700$). There was a high prevalence of asthenopia among computer science students, mostly caused by refractive asthenopia. Accommodation measurements should be performed more routinely and regularly, maybe as screening, especially in computer users.

Keywords : Asthenopia, acomodative insufficiency, computer users, students

INTRODUCTION

The number of computer users has rapidly increased throughout the world and is expected to reach 1 billion by the year 2010 as a result of an increasing number of new computer users in developing countries such as China, India and Russia.⁽¹⁾ There is a growing body of evidence

that the use of computers can adversely affect visual health. Working at a computer terminal is invariably associated with ocular disorders that may affect visual acuity. Initially research was focused on the ocular effects of radiation hazards, but subsequently came to include symptoms due to exposure of the eyes to video display terminals (VDT), known as the

computer vision syndrome.⁽²⁾ Several studies showed that around 75% of computer users had visual problems.^(3,4) Symptoms frequently reported by computer users were eyestrain, tired eyes, irritation, redness, blurred vision, diplopia, burning of the eyes, and asthenopia.⁽⁵⁻⁷⁾

The main cause of asthenopia is thought to be fatigue of the ciliary and extraocular muscles due to the prolonged accommodation and vergence required by near vision work. Another causative factor that has been implicated in asthenopia is dryness of the eyes resulting from an increased exposed surface area of the cornea when focusing straight ahead (rather than down at written text) and a decreased blink rate due to mental concentration.^(8,9)

Etiologically, asthenopia may be classified as muscular asthenopia and refractive asthenopia. Muscular asthenopia may be caused by heterophoria, intermittent heterotropia, and convergence insufficiency (CI), whereas refractive asthenopia is due to ametropia, presbyopia, accommodative insufficiency (AI), and a combination of accommodative and convergence insufficiency. Anomalies of convergence may be detected by means of the near point convergence (NPC) test, while accommodative abnormalities are detected by the near point accommodation (NPA) test.⁽¹⁰⁾ Symptoms occurring in asthenopia are redness, heaviness of the eye, dry eye, frontal headache with periocular pain and occipital headache, blurred vision, intermittent diplopia at near fixation, and difficulty of focus, especially when reading and writing.⁽¹¹⁾ Computer-related headache and eyestrain are reported during as many as 10% to 15% of routine eye examinations, and several investigators state that nearly 50% of VDT workers experience some eye discomfort. The World Health Organization has initiated a program to eradicate blindness in the year 2020, known as Vision 2020.⁽¹²⁾

Asthenopia is a reversible condition and does not result in a reduction of performance

or efficiency of the patient. Refractive asthenopia can be corrected by glasses, whilst muscular asthenopia may be corrected by accommodative and convergence training. Current technological advances can prevent asthenopia symptoms through appropriate ergonomic design of the VDT.⁽¹³⁾ Available data show that there are large numbers of computer and internet users. Consequently, the risk of asthenopia in computer users may reach epidemic proportions in the foreseeable future. The purpose of the present study was to determine the prevalence of asthenopia and its etiology in computer users.

METHODS

Design of the study

This study was an analytical study with cross-sectional approach, with the objective of determining the prevalence of asthenopia, in order to ascertain the extent of ocular health hazards resulting from computer use. The study was conducted in February 2007 at the Faculty of Medicine, University of Indonesia, Jakarta.

Subjects of study

The subjects of this study comprised 99 students from the Faculty of Computer Science, University of Indonesia. The inclusion criteria in this study were *strata 1* and *strata 2* students with visual acuity of 6/6 with or without correction who were willing to fill in the questionnaire and to receive an ophthalmological examination. The exclusion criteria were presence of manifest heterotropia, amblyopia, and ocular disorders capable of obstructing the visual axis.

Data collection

Data collection was carried out by means of a questionnaire and several ophthalmological tests. The data collected by questionnaire comprised demographic status, total hours of near-vision work and 15 items on subjective complaints due to asthenopia. Responses to the

15 items in the questionnaire were scored as follows: 0, never; 1, infrequent; 2, occasionally; 3, relatively frequent; 4, frequent; and 5, always. The total score for the 15 questions given to each subject ranged from 0 to 75. Subjects were considered to be at risk of suffering from convergence insufficiency if their total score was ≥ 9 . Subjects having a total score of < 9 were assigned to the group with negative symptoms, while those with a total score of ≥ 9 were placed in the group with positive symptoms.⁽¹⁴⁾

Subsequently the subjects received an ophthalmological examination, comprising determination of visual acuity, the Hirschberg test, tests for NPA, amplitude accommodation (AA), and NPC, the cover test (CT), and the alternate cover test (ACT). Subjects were diagnosed as suffering from AI if the obtained AA score was less than the normal score for age according to Donder’s table.⁽¹¹⁾ The AA score for the age range of 17-19 years is ≥ 11 D, 20-24 years 8 D, 25-29 years ≥ 6 D, 30-34 years ≥ 5 D, and 35-39 years ≥ 4 D (D=dioptries).

NPC is the convergence ability of the patient’s eye in maintaining fusion, and the test result is expressed in cm. A score of < 10 cm is said to be normal and a score of > 10 cm means that the subject has CI.⁽⁸⁾

Data analysis

The study data were divided into two groups, i.e. data on the group of subjects with asthenopia and data on the group of normal subjects. The relationships between variables of the asthenopia group and the normal group were analyzed using the chi square tests. A p-value of < 0.05 was considered significant. The data analysis used the SPSS program version 15.0.

RESULTS

The total number of subjects who were willing to participate in this study was 133, of whom 34 did not meet the inclusion criteria, for the following reasons: one subject had

congenital cataract, four subjects suffered from manifest heterotropia, and 29 subjects did not complete the questionnaire. The total number of subjects who participated until completion of the study was 99, consisting of 61 (61.4%) males and 38 (38.4%) females. Mean age of the subjects (\pm SD) was 20.2 ± 1.8 years, with a range of 18 up to 26 years. The majority of the subjects (68 persons or 68.3%) used a computer from 3-6 hours per day, and only 7 (7.1%) used a computer for ≤ 2 hours per day. The prevalence of asthenopia in the present study was 69 (69.7%), while that of normal subjects was 30 (30.3%).

Table 1 shows the distribution of etiologies of the asthenopic subjects. Among the two principal causes of asthenopia, i.e. refractive anomalies and muscular anomalies, refractive anomalies accounted for the majority of asthenopia causes (95.7%), where AI ranked highest at 50.7%.

The results of the analysis (Table 2) indicated that there was a significant difference between the two groups for the symptoms of visual fatigue ($p= 0.031$), heaviness ($p=0.002$), difficulty of recall of recent reading ($p=0.001$), parietal or occipital headaches ($p=0.000$), blurred vision ($p=0.001$), confusion during reading ($p=0.014$), and failing focus or loss of concentration during reading ($p=0.003$). Most of the subjects in the asthenopia group were active at the computer for 2-4 hours per day.

Table 1. Distribution of etiologies of asthenopia

Etiology of asthenopia	n	%
Refractive anomalies		
Myopia	15	21.7
Astigmatism	2	2.9
Compound myopic astigmatism	3	4.3
Combination of AI and CI	11	15.9
Accommodative insufficiency (AI)	35	50.7
Muscular anomalies		
Heterophoria	0	0
Intermittent heterotropia	0	0
Convergence insufficiency (CI)	3	4.3

Table 2. Analysis of subjective complaints between asthenopia and normal groups

Complaints	p
Visual fatigue	0.031*
Redness	0.106
Heaviness in eye	0.002*
Dry eye	0.088
Drowsiness	0.184
Difficulty of recall of recent reading	0.001*
Periocular pain	0.229
Parietal/occipital headaches	0.000*
Blurred vision	0.001*
Occasional diplopia	0.103
Line skipping during reading	0.207
Confusion during reading	0.014*
Difficulty of focus/loss of concentration	0.003*
Need for momentary rest for the eyes	0.052
Floating text	0.695

* Significance

From Table 3 it is apparent that duration of daily computer use was not significantly associated with occurrence of asthenopia (p=0.700).

DISCUSSION

To date the use of computers has spread extensively throughout the world and accompanying ocular complaints occur in 75-90% of the population of computer users.⁽²⁾ The present study showed a high prevalence of asthenopia of 69.7% in computer users. Essentially similar results were obtained in an Indian study on computer users aged 18-55 years, of whom 46.3% suffered from asthenopia.⁽¹⁾ A study in Italy on bank employees

found that 39.1% of the subjects had asthenopia.⁽⁵⁾

A total of 92.9% of computer science students in our study had ocular complaints, of whom 69.7% suffered from refractive anomalies. Blehm et al. obtained similar results, where 75-90% of computer users had ocular complaints.⁽²⁾ In all probability their subjects had ocular surface abnormalities and photophobia, which were not investigated in their study. Ocular surface abnormalities are caused by dry eye and problems with contact lenses. Dry eye may be due to reduced blinking reflexes and environmental factors.^(1,2) Photophobia is sensitivity of the eye to light, and computer users are commonly exposed to intense illumination and monitor flicker.⁽¹⁶⁾ The usual cause of intense illumination is a window facing the operator and a less than adequate ambient lighting.

AI is the major cause of asthenopia, because computer-related activities overburden the accommodation mechanism. The concurrence of refractive errors leads to an increased probability of subjective complaints. The occasional occurrence of blurred vision is due to failure of the accommodative mechanism to maintain focus on near objects. Blurred vision may be remedied by fitting a positive spherical lens or by accommodative training, in which case the subject with AI is fitted with a spherical lens of +0.75D up to +1.25D for near vision.⁽¹⁷⁾ Accommodative training may be accomplished by means of the flip lens technique,^(3,4) which uses 2 negative spherical lenses and 2 positive spherical lenses, each differing 0.5D in power.

Table 3. Distribution of asthenopia in relation to duration of computer use (hours/day)

Duration of computer use (hours/day)*	Asthenopia		p
	Present (%)	Absent (%)	
≤ 2	4 (57.1)	3 (42.9)	0.700
3-4	27 (73.0)	10 (27.0)	
5-6	20 (64.5)	11 (35.5)	
> 7	18 (75.0)	6 (25.0)	

* Chi-square test

The patient is asked to focus on an object located at a distance of 40 cm in front of her, then the lenses are placed in turn, with the patient attempting to maintain focus on the object. The procedure is repeated 5 times daily, each time for a period of 3 minutes.

CI is a condition where a person lacks the ability for maintaining binocular convergence. This condition is the most frequent cause of muscular asthenopia, being found in 3-5% of the general population.⁽⁵⁾ and in 4.3% of the asthenopia group of the present study. CI may be managed by convergence training, also known as pencil push up,⁽¹⁹⁾ where the patient focuses on her thumb or on a pencil held in her hand. The object is held vertically at arm's length in front of the eye, then the object is slowly moved towards the eye, while the patient attempts to maintain binocular convergence. This procedure is performed 3-4 times daily for 5 minutes and in general the patient will recover within 5-15 weeks.

Refractive errors most frequently encountered are myopia (21.7%), astigmatism (2.9%), and compound myopic astigmatism (4.3%), which may be corrected with glasses.⁽¹⁸⁾ On the other hand, the combination of AI and CI is managed by accommodative and convergence training.⁽⁶⁾

In the asthenopia group of the present study, computer-related activities were apparently more frequent than other types of near work. There are still conflicting opinions on the relationship of duration of computer use to occurrence of asthenopia. A total of 73.0% of subjects with asthenopia performed computer-related activities for periods of 3-4 hours per day, but no significant association was found between duration of computer use and the occurrence of asthenopia. In contrast, a study in India found that mean computer use of 78 minutes duration was associated with occurrence of asthenopia.⁽⁵⁾

Seven subjective complaints were proven to be significant in the asthenopia group, i.e. visual fatigue ($p=0.031$), heaviness ($p=0.002$),

difficulty of recall ($p=0.001$), blurred vision ($p=0.001$), parietal or occipital headaches ($p=0.000$), confusion during reading ($p=0.014$), and failing focus or loss of concentration during reading ($p=0.003$). Visual fatigue and heaviness in the eye may be caused by inability to maintain binocular fixation, occurring in subjects with CI.⁽³⁾ Blurred vision and failing focus are due to inability of the accommodation mechanism to maintain focus on near objects, as found in subjects with AI. In subjects with poor accommodation there also occur headaches when reading.⁽¹⁹⁾ The above symptoms may diminish and disappear with management of the asthenopia. Improving the ergonomic design of workstations and modifying the work habits of computer users (with supplementary breaks) have been shown to have positive effects on visual fatigue in these workers.^(20,21)

Asthenopia has been extensively studied in the computer literature, and the most commonly used assessment method is self-reporting, because this is a rapid and inexpensive method that can be applied to general populations. However, the method carries the risk of self-reporting bias, whereby the personal experiences of the respondent may affect the recall, interpretation, and reporting of symptoms.

CONCLUSIONS

This study suggests that asthenopia is a common problem among students who are computer users and is mostly caused by accommodative insufficiency.

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