Article • Accommodative and Vergence Dysfunctions Manifest Visual Symptoms in Emmetropic Thangka Artists

Gauri Shankar Shrestha, M.Optom • Institute of Medicine • Kathmandu, Nepal
Deepa Dhungel, B.Optom • Institute of Medicine • Kathmandu, Nepal
Romina Shrestha, MN, MA • Institute of Medicine • Kathmandu, Nepal
Sharmila Neupane, MN, MEd • Institute of Medicine • Kathmandu, Nepal
Nabaraj Gautam, PhD • Institute of Medicine • Kathmandu, Nepal
Niraj Dev Joshi, B.Optom • Institute of Medicine • Kathmandu, Nepal
Sanjeeb Kumar Mishra, M.Optom • Institute of Medicine • Kathmandu, Nepal

Gauri Shankar Shrestha, M.Optom
Kathmandu, Nepal
Lecturer, Institute of Medicine, Nepal
Program Coordinator (2014-2018)
B.Optom, Institute of Medicine, Nepal 2002
M.Optom, Bharati Vidyapeeth University, India 2007
PhD, UNSW Sydney, Australia, Ongoing

ABSTRACT

Background: Prolonged near work is a potential source of visual problems, which deteriorates work performance and reduces productivity. The present study aims to report the association between visual symptoms and ocular-visual abnormalities in thangka artists.

Methods: In a descriptive cross-sectional study, 342 emmetropic thangka artists were enrolled in the study from six randomly selected clusters of thangka painting schools from Kathmandu. Before eye examination, the Nepali version of the questionnaire on the symptoms of visual strain was administered to every subject to assess visual symptoms. Eye examination included visual acuity testing, refraction, cover test, fusional vergence, amplitude of accommodation, lag of accommodation, accommodative facility, convergence, Schirmer test, blink rate, colour vision, and stereopsis. Multivariate logistic regression analysis was used to determine the association between symptoms and ocular-visual abnormalities.

Results: Accommodative insufficiency ($p<0.001$) and accommodative infacility ($p=0.001$) were significantly associated with middle-age adults (>30 years). Regarding visual symptoms, blurred vision (56.4%) and burning eyes (56.0%) were reported with the greatest frequency. However, tired eyes and double vision were mostly correlated with ocular-visual abnormalities. Tired eyes was especially correlated with accommodative infacility ($p<0.001$) and accommodative insufficiency ($p=0.001$), whereas double vision was correlated with fusional insufficiency at both distance ($p=0.001$) and near ($p=0.048$).

Conclusion: Thangka artists have a greater prevalence of ocular-visual abnormalities, along with visual symptoms. Accommodative insufficiency, accommodative infacility, and fusional insufficiency are associated with symptoms of tired eyes and double vision in this population.

Keywords: accommodative anomalies, asthenopia, convergence insufficiency, double vision, dry eye, watering

Introduction

Near work has long been considered a potential source of visual difficulty,[1,2] which usually deteriorates work performance and reduces productivity.[3,4] Despite proper refractive correction or absolute emmetropia, vision-related problems can be observed because of sustained accommodative and vergence response to viewing any form of near target. Amalia et al. reported poor accommodation correlated with headaches while reading.[5] However, various symptoms such as blurred vision, ocular discomfort, ocular fatigue, systemic fatigue, diplopia, motion sickness, and loss of concentration can also be noted with accommodative and vergence anomalies. Dry eye symptoms are also significantly associated with near work.[6,7] Reduced blink rate is one of the major causes of dry eye symptoms

among computer users,[8] which may exaggerate the symptoms of pre-existing dry eye.[9]

Thangka is a Tibetan Buddhist painting on cotton, silk appliqué, usually depicting a Buddhist deity, scene, or mandala. There are two theories as to why asthenopic symptoms may be greater among thangka artists: first, they are exposed to prolonged and repetitive near work using art materials, and second, thangka painting involves fine and precise designs and details, which require high visual attention and mental concentration. Going one step further, the colours used for the paintings can be toxic and have detrimental visual and neurological effects.[10-15]

We have previously presented the association between significant refractive error (myopia ≥ -0.50 D, hypermetropia ≥ +0.50 D, and astigmatism ≥ -0.50 D) and visual symptoms among thangka artists. The most-reported symptoms were blurred vision, dry eye, and watering of the eyes. Visual symptoms were correlated with astigmatism.[6] The present study aims to report the association between visual symptoms and binocular vision anomalies among emmetropic thangka artists.

Methods

Subjects and study design

This convenience-sampling, cross-sectional study was performed using thangka schools with a group of 50 or more artists working in the schools. Selection criteria for candidates included those who worked for approximately 48 hours per week for two or more years consecutively. The candidates were below the age of 40 years, had no systemic illnesses, were not taking any medicine for chronic diseases, had visual acuity equal to or better than 0.1 Log MAR, had full extraocular movements in all cardinal gazes, and who consented to participate in the study. Any artists who had previous eye surgeries or were amblyopic or strabismic were excluded.

In the study, 364 emmetropic participants (myopia < -0.25 D, hypermetropia < +0.25 D, and astigmatism < 0.25 D) were enrolled from November 2015 to December 2016 from six clusters of the thangka painting schools of the Kathmandu valley. There were 22 normal individuals excluded from further analysis due to incomplete information regarding visual symptoms. For the present study, two groups were compared: 234 emmetropic participants with accommodative and vergence abnormalities and 108 emmetropic participants with normal ocular findings.

Informed consent was obtained from all participants, and the study was approved by the ethics committee of the Institutional Review Board of the Institute of Medicine. The research protocol adhered to the provisions of the Declaration of Helsinki for research involving human subjects.

Assessment

Structured questionnaire

The visual symptoms questionnaire consists of nine items. Each item is scored on a scale from 0 (no symptoms) to 6 (very severe symptoms). The higher the score, the greater the symptoms. Detailed descriptions of the questionnaire's development to Nepali script from the original English version and its application, along with its reliability, are given elsewhere.[6] The questionnaires was completed by participants before commencement of the eye examination. Each questionnaire was read slowly and clearly for each subject separately, and they were asked for their best response. The intraclass correlation coefficient (Cronbach's alpha) of visual symptoms for the present study sample was noted to be 0.759 (95% CI, 0.719-0.796). Symptoms were classified as internal symptoms or external symptoms for analysis in the study.

Clinical Assessment

Blink rate was measured as blinks per minute while reading a Nepali newspaper without informing the candidates about the nature of the evaluation (Table 1). Tear secretion was measured with the Schirmer strip by placing its notch in the lateral 1/3rd of the lower cul-de-sac for five minutes. Unaided, aided, and best-corrected visual acuity were assessed with the log MAR chart placed at a distance of three meters. Objective and subjective refraction were performed at six meters. Extraocular movement was assessed with the help of a torchlight at six cardinal gazes to detect any restriction. Cover test was performed at six meters for far and 40 cm for near to measure heterophoria. The Worth 4-dot test was performed to assess suppression at distance and near. The near point of convergence (NPC) and amplitude of accommodation were measured using the Royal Air Force ruler. Accommodative facility was measured binocularly with ±2.00 D lens flippers at 40 cm while viewing letters of N8 size. Positive fusional vergence (PFV) and negative fusional vergence (NFV) were measured at far and near near binocularly using a horizontal prism bar before one eye, increasing the power of the prism gradually until subjects first noticed a break. Lag of accommodation was measured using

Table 1. Diagnostic Criteria for Various Ocular Findings

Condition	Characteristics
Reduced blink rate	< 12 blinks per minute
Reduced tear secretion	Wetting of the strip less than 10 mm in 5 min
Emmetropia	Refractive error as follows: myopia < -0.25 D, hypermetropia < +0.25 D, astigmatism < 0.25 D
Exophoria	>4 pd for distance and 6 pd for near
Esophoria	>2 pd for distance and 4 pd for near
Accommodative insufficiency	Accommodative amplitude 2.00 D (or more) less than age-expected by Hofsetters formula
Convergence insufficiency	NPC > 10 cm, exophoria at near, reduced positive fusional vergence
Accommodative infacility	Accommodative facility < 10 cycles per minute
Lag of accommodation	> +0.75 D
Fusional insufficiency	PFV (break <21 pd for near and <19 pd for distance) with no exophoria
Fusional excess	NFV (break <16 pd for near and <8 pd for distance) with no esophoria
Color vision defect	> 6.0 plates error in counting
Reduced stereopsis	Worse than 60 sec of arc

NPC = near point of convergence, PFV = positive fusional vergence, NFV = negative fusional vergence, pd = prism dioptre

Table 2. Distribution of Symptoms of Visual Strain Among Thangka Artists

Symptom	Symptoms reported for at least once in percentage		Percentage symptom scores		Median		p-value
	Case	Healthy subjects	Case	Healthy subjects	Case	Healthy subjects	
General visual discomfort	26.1	17.0	27.0	23.1	1	1	**0.02**
Internal symptoms							
Tired eyes	50.4	41.5	38.2	33.0	2	1	0.26
Blurred vision	56.4	39.6	40.6	34.9	2	1	0.06
Double vision	26.5	17.0	27.8	20.9	1	1	**0.005**
Sore or aching eyes	49.1	41.5	37.7	34.6	1	1	0.67
External symptoms							
Watering	50.4	50.9	35.2	33.9	2	2	0.81
Dry eyes	41.0	24.5	32.9	26.2	1	1	**0.007**
Burning eyes	56.0	52.8	41.2	35.8	2	2	0.26
Irritated eyes	43.6	33.9	31.5	27.7	1	1	0.34

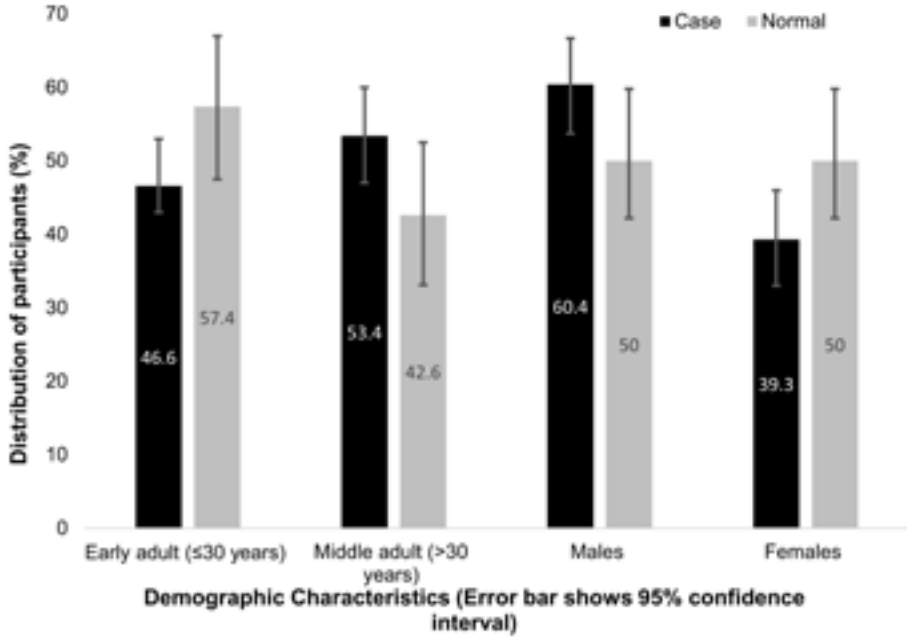

Figure 1. *Age and sex distribution of thangka artists (p-value insignificant for age distribution (p = 0.06) and gender distribution (p = 0.06) by chi-square test)*

dynamic retinoscopy by presenting the N8 target at the retinoscopy plane in normal room illumination. Colour vision was assessed with the Ishihara 38 plates at 50 cm in normal room illumination, and stereopsis was measured with the Titmus fly test at 40 cm. Anterior and posterior segment examination was carried out with the help of a portable slit lamp and direct ophthalmoscopy.

Data Analysis

All data were reviewed and analyzed using the Statistical Package for Social Sciences version 22.0. Age was classified into two groups: early adults (16-30 years) and middle adults (31-40 years). Descriptive statistics were presented as frequency, percentage, mean, and standard deviation. The visual symptoms were presented as median and percentage symptom scores and compared between case and normal subjects. Multinomial logistic regression analysis was used to determine the association between the symptoms and clinical findings. In all analyses, a significance level of 0.05 was applied for a 95% confidence interval.

Results

The age and sex distribution of thangka artists for cases and normal subjects is presented in Figure 1. Age ($p = 0.06$) and sex ($p = 0.06$) distributions noted between the cases and the normal subjects were not significant. However, the mean age was significantly higher ($p = 0.007$) among the case group (29.7 ± 6.8) as compared to normal subjects (27.5 ± 6.8).

The abnormal ocular-visual findings among thangka artists (cases) are presented in Figures 2 and 3, by age and sex, respectively. Reduced blink rate showed the highest prevalence (53.8%), followed by fusional insufficiency at distance (52.6%), accommodative infacility (41.0%), fusional insufficiency at near (32.9%), accommodative insufficiency (24.4%), lag of accommodation (22.2%), reduced tear secretion (18.4%), and convergence insufficiency (17.1%). Among the findings, accommodative insufficiency ($p = 0.001$) and accommodative infacility ($p < 0.001$) were significantly associated with middle-aged adults. Convergence insufficiency was reported commonly in males ($p = 0.047$).

The distribution of visual symptoms among thangka artists is presented in Table 2. The three most common symptoms were burning eyes (41.2%), blurred vision (40.6%), and tired eyes (38.2%), among those with a visual condition. However, case subjects and normal subjects had significantly different symptom scores: dry eye (32.9% vs 26.2%; $p = 0.007$), double vision (27.8% vs 20.9%; $p = 0.005$), and general visual discomfort (27.0% vs 23.1%; $p = 0.02$).

Multinomial logistic regression analysis between ocular findings and visual symptoms is presented in Table 3. There were scattered correlations between these variables, which were mostly observed between the group of internal symptoms and ocular findings. Among them, tired eyes ($p = 0.006$) and aching eyes ($p = 0.003$) were correlated with female gender. Tired

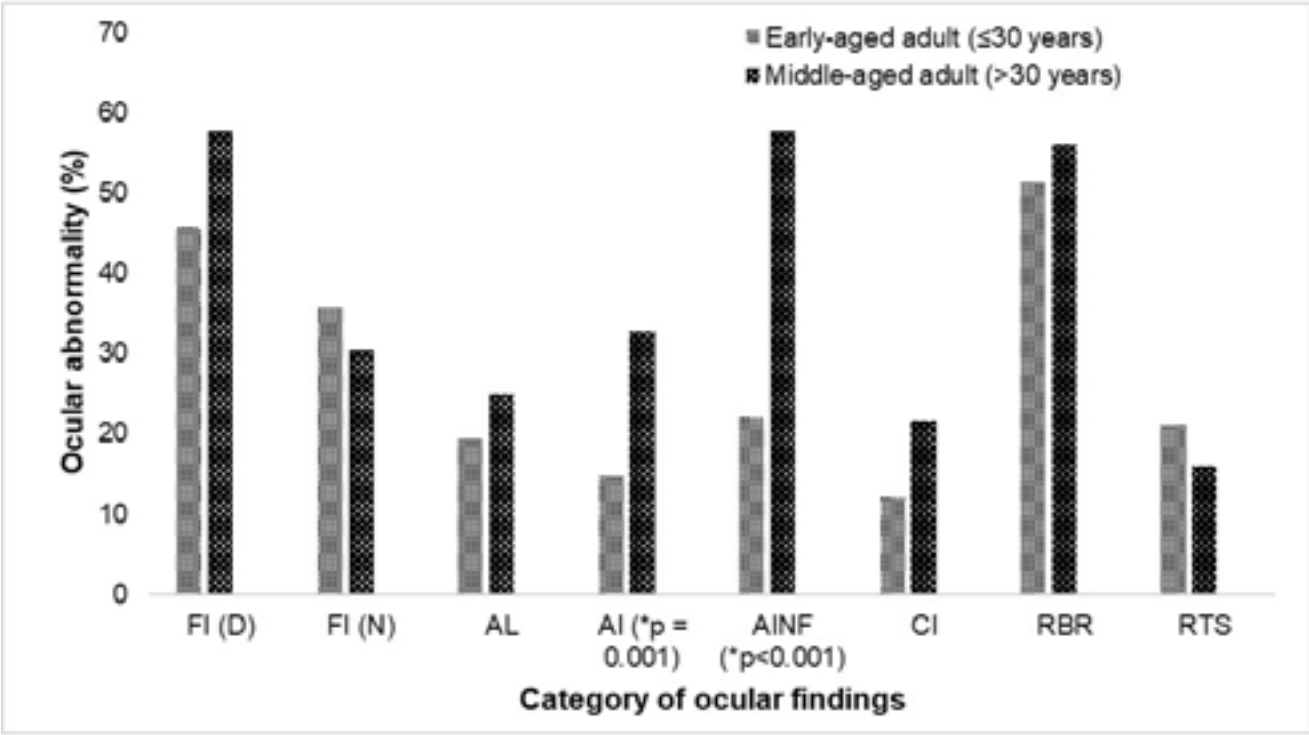

Figure 2. *Prevalence of ocular abnormality among thangka artists by age group (FI = fusional insufficiency, D = distance, N = near, AL = lag of accommodation, AI = accommodative insufficiency, AINF = accommodative infacility, CI = convergence insufficiency, RBR = reduced blink rate, RTS = reduced tear secretion, * p-value significant at 0.05 by chi-square test, # p-value significant at 0.05 by Yates' chi-square test)*

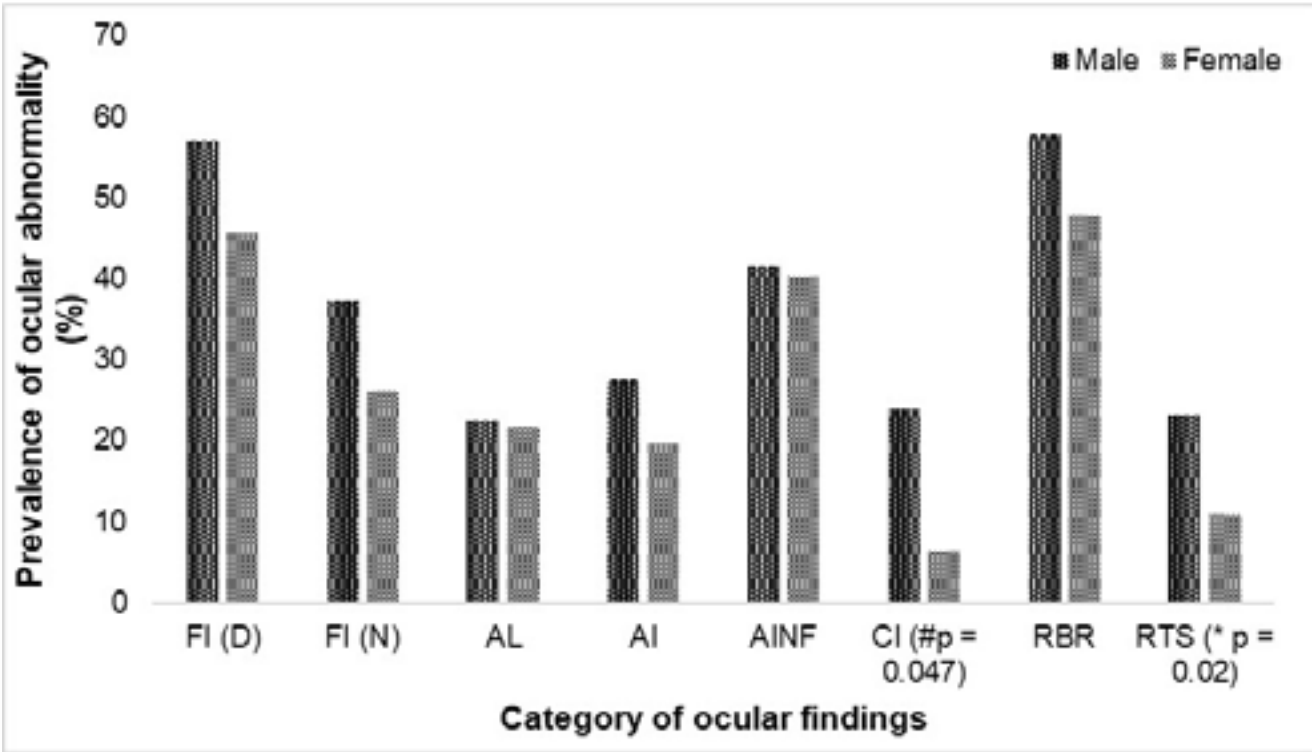

Figure 3. *Prevalence of ocular abnormality among thangka artists by gender (FI = fusional insufficiency, D = distance, N = near, AL = lag of accommodation, AI = accommodative insufficiency, AINF = accommodative infacility, CI = convergence insufficiency, RBR = reduced blink rate, RTS = reduced tear secretion, * p-value significant at 0.05 by chi-square test, # p-value significant at 0.05 by Yates' chi-square test)*

Table 3. Distribution of Symptoms of Visual Strain Among Thangka Artists

	Dependent variable								
General visual discomfort	Internal symptoms				External symptoms				General discomfort
	Tired eyes	Aching eyes	Double vision	Blurred vision	Dry eyes	Burning eyes	Irritated eyes	Watering eyes	
Age	0.48	0.98	0.57	0.19	0.26	**<0.001**	-	0.61	**<0.001**
Sex	**0.006**	**0.003**	0.83	0.08	0.12	**0.001**	**<0.001**	0.76	**<0.001**
Fusional insufficiency (distance)	**0.006**	**0.02**	**0.001**	0.52	0.31	**<0.001**	-	0.57	**0.01**
Fusional insufficiency (near)	0.37	0.95	0.048	0.32	0.39	**<0.001**	-	**0.001**	0.83
Accommodative lag	0.189	**0.04**	0.31	0.29	0.87	**<0.001**	0.31	0.47	0.13
Accommodative insufficiency	**0.001**	0.95	0.26	0.49	0.31	**-**	-	0.16	**<0.001**
Accommodative infacility	**<0.001**	0.88	0.20	0.15	0.19	**<0.001**	-	0.23	**0.001**
Convergence insufficiency	0.076	0.28	0.40	0.17	**0.01**	-	**0.001**	0.21	0.17
Reduced blink rate	0.49	0.09	0.79	0.70	**0.001**	-	**0.003**	**0.009**	0.34
Reduced tear secretion	0.56	0.32	**0.001**	0.06	0.18	-	0.12	0.12	**0.01**
Model fit	**<0.001**	**0.001**	**0.03**	**0.008**	**<0.001**	1.0	0.65	0.07	1.0

eyes were noted to be correlated with accommodative anomalies such as accommodative insufficiency ($p = 0.001$) and accommodative infacility ($p < 0.001$). Double vision was correlated with fusional insufficiency at distance ($p = 0.001$) and near ($p = 0.048$).

Discussion

Visual problems related to prolonged near work are commonly reported in the literature. The present study shows that prolonged near work induces visual symptoms among thangka artists despite normal acuity and refraction.

The health hazards of artists have broadly been reported in the literature, ranging from systemic conditions like neurological deficits, tremors, cognitive impairments,[10] allergy, and irritative symptoms of the skin[13] to ocular disorders such as colour vision defect,[10,11] cataract, glaucoma, and retinal detachment and degeneration.[11] Thangka artists work with various kinds of pigments, solvents, and metals; the risk of health hazard and the manifestation of symptoms from these chemicals cannot be ignored.[10,13,15] Our study is unique in that the case and normal subjects are drawn from a similar group of artists in a similar work environment with a similar duration of work. Moreover, ethnic distribution was also homogenous (Newar, 32.9%; Tamang, 66.7%). Regarding colour vision defects, 11 subjects in the case group were noted to have an error in reading 2 to 3 colour plates, which was not sufficient to label them as having a colour vision defect.

We have already reported the ocular-visual problems associated with uncorrected refractive error among thangka artists, where ocular astigmatism was correlated with symptoms like sore eyes ($p = 0.003$), feeling dry ($p = 0.005$), and blurred vision ($p = 0.02$).[6] Earlier, a new approach was suggested to explain the visual problems and the association between near tasks and accommodative and vergence findings.[1] These symptoms are reported to be ambiguously associated with various clinical findings: binocular vision anomalies such as convergence insufficiency and esophoria[16-18] and accommodative dysfunctions such as accommodative insufficiency and accommodative infacility.[19-21]

Thangka artists do intense near work and require extreme hand-eye coordination. Therefore, the rate and intensity of symptoms and ocular-visual abnormalities may vary to some extent compared with other professions. For instance, 34.7% of the thangka artists reported symptoms of visual strain, which was slightly less than the asthenopic symptoms reported by computer users (69.7%),[5,22] overall visual symptoms reported by thangka artists with refractive errors (45.6%),[6] and those in jewelry manufacturing (65.2%).[23] Among individual symptoms, blurred vision (56.4%) and burning sensation (56.0%) were the most reported by our subjects after long hours of painting. The Untimanon et al. study reported eye burning (26.6%), eye pain (14.0%), and eye irritation (11.2%) among electronics and jewelry workers.[24] Chiemeke et al. reported the most common visual problems

among computer users as eyestrain, blurred distance vision, headache, double vision, and redness. Eyestrain was the most severe.[25] In our previous report on VDT users, blurred vision (64.5%) was the most common visual symptom, and tired eyes (88.2%) and sore eyes (71.1%) were the two most common ocular symptoms reported.[26] Similarly, blurred vision (69.5%) and sore eyes (61.0%) were the two most common visual symptoms reported among thangka artists with refractive error in our previous study.[6] Although visual symptoms were apparently noted slightly less in thangka artists than other professionals, they shared a common form of visual symptoms. The proportion of symptoms among them cannot be neglected in terms of a public health perspective.

Blink rate was reduced in 126 participants (53.8%), whereas the Schirmer test was reduced in only 43 participants (18.4%). The blink rate and Schirmer test scores were significantly different, as indicated by chi-square test ($X^2 = 11.1$, df = 1, $p = 0.001$). Surprisingly, tear secretion was found to be significantly more reduced in males than females ($X^2 = 5.69$, df = 1, $p = 0.02$). One of the reasons for this discrepancy could be related to the distribution of males and females in the case group. The majority of the middle-aged group was male (n = 93, 74.4%) whereas the majority of the younger-aged group was female (n = 60, 55.0%). There was a significant variation ($X^2 = 21.2$, df = 1, $p < 0.001$) in gender distribution.

In the literature, dryness symptoms like asthenopia and reduced blink rate are higher among computer users.[27,28] Thangka artists also followed a similar trend of dry eye symptoms ($p = 0.007$). The symptom of dryness was associated with decreased blink rate ($p = 0.001$) and convergence insufficiency ($p = 0.01$), but not with the Schirmer test. We did not assess the tear break up time, which has been reported to be firmly associated with poor blinking, leading to visual conditions and asthenopia.[29] We understand that cognitive load[8,28,30] and visual stress[31,32] could relate to a reduced blink rate in this population. In addition, we did not assess the blink rate in a real work environment, which could have a more valid and robust meaning.

Positive fusional vergence was markedly reduced by 52.6% and 32.9% for distance and near, respectively. It was significantly correlated ($p = 0.001$ for distance and $p = 0.048$ for near) with the symptom of double vision. Double vision was also correlated with a reduced Schirmer score ($p = 0.001$). Sedaghat and Abrishami reported that asthenopic symptoms in general were associated with negative fusional vergence among exophoric patients with a low degree of myopia.[33] In that study, subjects with moderate to severe dry eye were excluded. Fusional insufficiency is one of the factors associated with convergence insufficiency, but in our study, they were not related ($X^2 = 31.8$, df = 1, $p < 0.001$). Fusional insufficiency at distance apparently seems to be a manifestation of adaptation to excessive visual demand for near work. At near, it seems to fatigue due to constant focusing, but this needs to be validated.

The third most common ocular-visual finding was accommodative dysfunction, consisting of accommodative infacility in 41.0%, accommodative insufficiency in 24.4%, and accommodative lag in 22.2%. Accommodative infacility ($p < 0.001$) and accommodative insufficiency ($p = 0.001$) were significantly associated with the middle-aged group. Iribarren et al. also reported that increased near work was significantly correlated with accommodative infacility and that it is more related to hard copy reading than computer use.[34] Moreover, the symptoms of blurred vision and burning eyes were also associated more with reading a hard copy, while red eyes had a greater association with computer use.[34] Tosha et al. reported that visual discomfort was related to an abnormal accommodative lag in prolonged viewing, indicating accommodative fatigue. However, the amplitude of accommodation was reported as being stable among subjects with visual discomfort.[35] In contrast, our study shows that accommodative infacility ($p < 0.001$), as well as accommodative insufficiency ($p = 0.001$), were associated with the symptom of tired eyes. Accommodative lag had no firm establishment with the symptoms. Association between blurred vision and accommodative insufficiency (50.7%) has been reported.[5] Shrestha et al. also reported a high incidence of accommodative disorders comprising 58.8% of total abnormalities detected among VDT users; accommodative infacility was the highest (35.5%).[26] Thangka painting presents a greater stimulus to accommodation than reading and computer use because it is usually done at a closer distance than reading while tracing very fine and detailed precision designs. Moreover, the painting is a dynamic process where a range of visual and cognitive attention is required. The amplitude and lag of accommodation are the more static measurements here, and the accommodative facility is the dynamic measure. Among these accommodative components, accommodative infacility may have more clinical implication. Iribarren et al. also reported

a relationship between the cumulative amount of time spent on near work over a period of years and reduced accommodative facility, suggesting that the cumulative amount of near work adversely affects the dynamics of the accommodative system in young individuals.[34,36] It is clear that the constant drifting and refocusing on fine patterns of paintings on canvas can lead to symptoms of visual strain.

Similarly, subjects showed exophoria at near (20.1%) greater than at distance (3.4%). The NPC was reduced in eight participants (3.4%, mild convergence insufficiency) and defective in 18 subjects (7.7%, severe convergence insufficiency), especially among males. Reduced NPC was found to be associated with symptoms of dryness. Such findings were expected as convergence insufficiency is well reported to be associated with asthenopic symptoms,[37,38] especially with headache, visual fatigue, and double vision.[37,39,40] When NPC is assessed with an accommodative target, it is typically better, and convergence insufficiency is found to be closely related to asthenopic symptoms.[41] We assessed NPC, positive fusional vergence, and phorias with a non-accommodative target. We have noted the lower frequency of convergence insufficiency comapred to other clinical findings. Unlike computer operators, thangka artists must perform eye-hand tasks at near quite frequently; thus, depth perception might have facilitated convergence. Further, convergence insufficiency and accommodative insufficiency are usually not distinguished in a typical questionnaire.[37,40,42,43] Symptoms of convergence insufficiency can be distinguished by considering symptoms like skipping lines, evening headache, double vision, and blurry words.[37,40,42,43] However, 13 subjects (37.1%) with convergence insufficiency also had accommodative insufficiency.

The present study has some limitations in its generalizability to other occupations. Systemic symptoms associated with near work were not included in the questionnaire, and relative accommodation was not measured.

Conclusion

It can be concluded that symptomatic thangka artists have a greater prevalence of oculo-visual abnormalities than asymptomatic thangka artists. Accommodative and fusional dysfunctions are related to the manifestation of visual symptoms.

References

1. Owens DA, Wolf-Kelly K. Near work, visual fatigue, and variations of oculomotor tonus. Invest Ophthalmol Vis Sci 1987;28(4):743-9.
2. Sheedy JE. The physiology of eyestrain. J Mod Optic 2007;54(9):1333-41.
3. Ip JM, Robaei D, Rochtchina E, Mitchell P. Prevalence of eye disorders in young children with eyestrain complaints. Am J Ophthalmol 2006;142(3):495-7.
4. Moore BD, Augsburger AR, Ciner E, Cockrell D, Fern K. Optometric clinical practice guideline: Care of the patient with hyperopia. Am Optom Assoc 1997:1-29.
5. Amalia H, Suardana GG, Artini W. Accommodative insufficiency as cause of asthenopia in computer-using students. Universa Medicina 2016;29(2):78-83.
6. Dhungel D, Shrestha GS. Visual symptoms associated with refractive errors among Thangka artists of Kathmandu valley. BMC Ophthalmol 2017;17(1):258.
7. Cooper JS, Burns CR, Cotter SA, Daum KM, Griffin JR, Scheiman M. Care of the patient with accommodative and vergence dysfunction. Am Optom Assoc 1998:5-10.
8. Gowrisankaran S, Nahar NK, Hayes JR, Sheedy JE. Asthenopia and blink rate under visual and cognitive loads. Optom Vis Sci 2012;89(1):97-104.
9. Rosenfield M. Computer vision syndrome: A review of ocular causes and potential treatments. Ophthalmic Physiol Opt 2011;31(5):502-15.
10. Dick F, Semple S, Chen R, Seaton A. Neurological deficits in solvent-exposed painters: A syndrome including impaired colour vision, cognitive defects, tremor and loss of vibration sensation. QJM 2000;93(10):655-61.
11. Ravin JG. The visual difficulties of selected artists and limitations of ophthalmological care during the 19th and early 20th centuries (an AOS thesis). Tran Am Ophthalmol Soc 2008;106:402.
12. Ivanišević P, Ivanišević M. The influence of retinal eye diseases on painting. Collegium Antropologicum 2015;39(1):243-6.
13. Wieslander G, Norback D, Edling C. Occupational exposure to water based paint and symptoms from the skin and eyes. Occup Environ Med 1994;51(3):181-6.
14. Nathan JJC, Optometry E. The painter and handicapped vision. Clin Exp Optom 2002;85(5):309-14.
15. Zuskin E, Schachter EN, Mustajbegovic J, Pucarin-Cvetkovic J, Lipozencic J. Occupational health hazards of artists. Acta Dermatovener Cr. 2007;15(3):167-77.
16. Sheedy JE, Saladin JJ. Phoria, vergence, and fixation disparity in oculomotor problems. Am J Optom Phys Opt 1977;54(7):474-8.
17. Sheedy JE, Saladin JJ. Association of symptoms with measures of oculomotor deficiencies. Am J Optom Phys Opt 1978;55(10):670-6.
18. Grisham JD. Visual therapy results for convergence insufficiency: A literature review. J Optom Physiol Opt 1988;65(6):448-54.
19. Hennessey D, Iosue RA, Rouse MW. Relation of symptoms to accommodative infacility of school-aged children. J Optom Physiol Opt 1984;61(3):177-83.
20. Levine S, Ciuffreda K, Selenow A, Flax N. Clinical assessment of accommodative facility in symptomatic and asymptomatic individuals. Am J Optom Physiol Opt 1985;56(4):286-90.
21. Jaschinski-Kruza W, Schweflinghaus W. Relations between dark accommodation and psychosomatic symptoms. Ophthal Physiol Opt 1992;12(1):103-5.
22. Vilela M, Pellanda L, Cesa C, Castagno V. Asthenopia prevalence

and risk factors associated with professional computer use: A systematic review. Int J Adv Med Sci 2015;3(2):51-60.

23. Salve UR. Vision-related problems among the workers engaged in jewellery manufacturing. Indian J Occup Environ Med 2015;19(1):30.
24. Untimanon O, Pacharatrakul W, Boonmeepong K, Thammagarun L, et al. Visual problems among electronic and jewelry workers in Thailand. J Occup Health 2006;48(5):407-12.
25. Chiemeke SC, Akhahowa AE, Ajayi OB, eds. Evaluation of Vision-Related Problems amongst Computer Users: A Case Study of University of Benin, Nigeria. World Congress on Engineering; 2007.
26. Shrestha GS, Mohamed FN, Shah DN. Visual problems among video display terminal (VDT) users in Nepal. J Optom 2011;4(2):56-62.
27. Blehm C, Vishnu S, Khattak A, Mitra S, Yee RW. Computer vision syndrome: A review. Surv Ophthalmol 2005;50(3):253-62.
28. Doughty MJ. Consideration of three types of spontaneous eyeblink activity in normal humans: During reading and video display terminal use, in primary gaze, and while in conversation. Optom Vis Sci 2001;78(10):712-25.
29. Liu H, Thibos L, Begley CG, Bradley A. Measurement of the time course of optical quality and visual deterioration during tear break-up. Invest Ophthalmol Vis Sci 2010;51(6):3318-26.
30. Patel S, Henderson R, Bradley L, Galloway B, Hunter L. Effect of visual display unit use on blink rate and tear stability. Optom Vis Sci 1991;68(11):888-92.
31. Gowrisankaran S, Sheedy JE, Hayes JR. Eyelid squint response to asthenopia-inducing conditions. Optom Vis Sci 2007;84(7):611-9.
32. Nahar NK, Sheedy JE, Hayes J, Tai Y-C. Objective measurements of lower-level visual stress. Optom Vis Sci 2007;84(7):620-9.
33. Sedaghat MR, Abrishami M. Comparison of amplitudes of fusional vergence in patients with asthenopic and asymptomatic near exophoria. Iran J Ophthalmol 2014;26(4):199.
34. Iribarren R, Fornaciari A, Hung GK. Effect of cumulative nearwork on accommodative facility and asthenopia. Int Ophthalmol 2001;24(4):205-12.
35. Tosha C, Borsting E, Ridder WH, Chase C. Accommodation response and visual discomfort. Ophthal Physl Opt 2009;29(6):625-33.
36. Ciuffreda KJ, Ordonez XJO. Abnormal transient myopia in symptomatic individuals after sustained nearwork. Optom Vis Sci 1995;72(7):506-10.
37. Borsting E, Rouse MW, De PL. Prospective comparison of convergence insufficiency and normal binocular children on CIRS symptom surveys. Convergence Insufficiency and Reading Study (CIRS) group. Optom Vis Sci 1999;76(4):221-8.
38. Scheiman M, Mitchell GL, Cotter S, Cooper J, Kulp M, Rouse M, et al. A randomized clinical trial of treatments for convergence insufficiency in children. Arch Ophthalmol 2005;123(1):14-24.
39. Porcar E, Martinez-Palomera A. Prevalence of general binocular dysfunctions in a population of university students. Optom Vis Sci 1997;74(2):111-3.
40. Borsting E, Rouse MW, Deland PN, Hovett S, Kimura D, Park M, et al. Association of symptoms and convergence and accommodative insufficiency in school-age children. Optom Vis Sci 2003;74(1):25-34.
41. Cohen Y, Segal O, Barkana Y, Lederman R, Zadok D, Pras E, et al. Correlation between asthenopic symptoms and different measurements of convergence and reading comprehension and saccadic fixation eye movements. Optometry 2010;81(1):28-34.
42. Borsting EJ, Rouse MW, Mitchell GL, Scheiman M, Cotter SA, Cooper J, et al. Validity and reliability of the revised convergence insufficiency symptom survey in children aged 9 to 18 years. Optom Vis Sci 2003;80(12):832-8.
43. Marran LF, De Land PN, Nguyen AL. Accommodative insufficiency is the primary source of symptoms in children diagnosed with convergence insufficiency. Optom Vis Sci 2006;83(5):281-9.

Correspondence regarding this article should be emailed to Gauri Shankar Shrestha, M.Optom, at gs101lg@hotmail.com. .

Shrestha GS N, Dhungel D, Shrestha R, Neupane S, Gautam N, Joshi ND, Mishra SK. Accommodative and vergence dysfunctions manifest visual symptoms in emmetropic thangka artists. Optom Vis Perf 2020;8(3):142-50.