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Physical Environment and Its Influence on Asthenopia: A Cross-Sectional Study among Batik Artisans in Klaten Regency, Indonesia

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Abstract
Introduction: Asthenopia, or eye strain, is a prevalent issue among batik artisans in Klaten Regency, Indonesia, due to the visually demanding nature of their work and potentially suboptimal working conditions.
Methods: This cross-sectional study investigated the influence of physical environmental factors, specifically lighting intensity, temperature, and humidity, on the occurrence of asthenopia symptoms among 155 female batik artisans. Data were collected through interviews using the Visual Fatigue Index questionnaire and environmental measurements.
Results: Most participants (65.8%) experienced asthenopia symptoms, with an average score of 0.47 (SD ±0.15). The most common symptoms included watery eyes, stinging sensations, gritty feelings, difficulty focusing, and heavy sensations in the eyes. Spearman's rank correlation revealed a statistically significant association between ambient temperature and asthenopia complaints ($p = 0.009$), while no significant correlations were found for lighting intensity ($p = 0.799$) and humidity ($p = 0.742$). The average workplace temperature was 28.61°C (SD ±1.04), exceeding the recommended comfort range of 23–26°C. Although 81.9% of participants worked under lighting levels below the recommended 300 lx, this factor was not significantly associated with asthenopia.
Conclusion: These findings highlight the importance of improving thermal comfort in traditional batik workplaces to reduce visual strain among artisans. Further research employing longitudinal and objective methodologies is recommended to better understand the complex interplay between environmental and individual factors contributing to asthenopia in this population.

Keywords: asthenopia, visual fatigue, occupational health, physical environment, temperature.

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Introduction

Maintaining optimal visual health is essential for individuals performing tasks requiring intense focus and precision. One such concern that affects visual health is asthenopia, or eye strain, which is characterized by symptoms such as eye fatigue, dryness, blurred vision, headache, and difficulty focusing.[1,2] This condition is particularly prevalent in activities that involve prolonged use of the eyes, such as reading or computer work.[3] The condition can also be exacerbated by factors such as poor ergonomics, inadequate lighting, and uncorrected refractive errors.[4–6] These factors not only contribute to immediate discomfort but can also have broader implications. Prolonged exposure to poor visual conditions in the workplace can lead to reduced productivity, and long-term health implications.[7]

Research has shown that the prevalence of asthenopia can differ based on the particular demographic and work environment being studied. In Iran, a study among university students revealed a significant prevalence of asthenopia at 70.9%, with women and those suffering from hyperopia and astigmatism being more prone to symptoms.[8] Among a different group of students at the American University of Beirut, the prevalence was slightly lower at 67.8%, with factors like the use of digital devices influencing the emergence of symptoms.[9] Occupational settings also show notable prevalence rates. In China, 40.7% of ophthalmologists reported suffering from asthenopia, with key factors such as insufficient sleep and excessive engagement in near-vision activities contributing significantly. On the other hand, maintaining good sleep quality and reducing near vision tasks served as protective measures against asthenopia.[10] While asthenopia has been widely studied in formal occupational settings, its prevalence and contributing factors in informal labor sectors remain underexplored. Recent studies indicate that individuals engaged in visually intensive traditional crafts, such as batik artisans, might face elevated levels of eye strain due to the detailed nature of their tasks and possibly less than ideal working conditions.[11]

Batik-making is a traditional art form that requires intricate and detailed work, often performed while sitting for long durations, with inadequate lighting and lacking proper ergonomic support. The lighting conditions in home-based batik workshops are often subpar, with illumination levels falling below the recommended 300 lx for tasks involving fine details. Light is unevenly distributed, and there is a heavy dependence on natural light or small local lamps, which fail to adequately light the area where wax is applied. This craft demands careful attention to intricate patterns, whether using a canting (wax tool) or a brush, placing considerable visual strain on the artisans.[12] In Klaten Regency, Central Java, batik production is not just an economic endeavor but also a practice that preserves cultural heritage. Many artisans operate from home-based or small-scale workshops that often lack adequate environmental controls. Elements of the physical environment, such as lighting intensity, temperature, humidity, and ventilation, are known to affect visual comfort and eye health.[13,14] Inadequate lighting, elevated temperatures, and poor air quality can intensify eye strain, especially when coupled with the visual demands of intricate craftsmanship. However, there is a lack of specific information regarding the effects of these environmental factors on the ocular health of batik workers in the informal sector.

While previous research has largely concentrated on individuals using digital screens or those in office jobs, there remains a notable lack of understanding of visual strain in artisanal work. Considering the visually intensive nature of batik production and the scarcity of empirical studies on this topic within the informal sector, this study explores how physical environmental factors affect the occurrence and intensity of eye strain among batik workers in Klaten Regency, Indonesia. The results of this study are expected to offer evidence-based insights for creating health interventions in the workplace, especially those designed for traditional craft industries and informal labor settings.

Methods

This study employed an observational design with a cross-sectional approach, conducted in July 2024 at 45 home-based batik production industries located in Jarum Village, Klaten Regency, Central Java, Indonesia. The research population consisted of 285 batik artisans, of which 155 respondents were selected through purposive sampling. To ensure that the sample was both focused and pertinent, the inclusion criteria specified that participants must be batik canting artisans actively engaged in the production process during the data collection period and willing to provide informed consent. Participants not involved in production activities at the time of the study or with physical conditions that hindered participation were excluded. Following these criteria, 155 artisans were selected for the study.

The independent variables in this study included physical environmental factors, specifically lighting intensity, temperature, and humidity. The dependent variable was the incidence of asthenopia. Additional data were collected on individual and occupational characteristics, such as age, years of service, and daily working hours. Lighting intensity was quantified using a lux meter, and temperature and humidity were measured using a thermo-hygrometer. Asthenopia complaints were assessed using the Visual Fatigue Index (VFI) questionnaire, which comprises 22questionss. In a prior study, the VFI questionnaire was validated through the Pearson product-moment correlation, and reliability analysis using Cronbach's alpha demonstrated a high degree of internal consistency, confirming the tool's appropriateness for evaluating visual fatigue in workplace environments. The VFI total score was determined by adding the responses to all 22 items. Each item is rated on a scale from 1 to 4, where 1 means never, 2 means occasionally, 3 means often, and 4 means always. Consequently, the total score can range from 22 to 88. To standardize the results, the total score was transformed into a relative index using the formula VFI = (Total of answers for each operator) / (Maximum possible total score). In this study, a VFI value of 0.4 or higher was used to signify the presence of visual fatigue (asthenopia), whereas a VFI below 0.4 indicated the absence of visual fatigue.

The study was approved by the Ethics Committee for Health Research of the Faculty of Nursing and Health Sciences, University of Muhammadiyah Semarang (Certificate Number: 417/KE/06/2024). Prior to commencing data collection, all participants provided written informed consent. The research methodology involved the administration of questionnaires through interviews, followed by environmental assessments of lighting, temperature, and humidity. Data analysis began with univariate analysis to describe individual and occupational characteristics, which were presented in frequency tables with values expressed as means ± standard deviation or median (minimum–maximum). Bivariate analysis was conducted using Spearman's rank correlation to evaluate the relationship between physical environmental factors and asthenopia complaints, given the numerical nature of the variables. All statistical analyses were performed using IBM SPSS Statistics (version 21).

Results

In this study, 155 individuals engaged in batik craftsmanship participated, all of whom were women with an average age of 44.36 years (SD ±8.41), ranging from 24 to 66 years old. The majority of the participants (68.4%) were between 45 and 64 years old. The mean body mass index (BMI) was recorded at 24.71 kg/m² (SD ±2.76), with the largest segment of respondents, 42.6%, classified as overweight, with a BMI between 25 and 29.9. Regarding work experience, the mean duration of service was 13.20 years (SD ±9.94), and more than half of the participants (65.2%) had worked for 10 years or more. The average daily working hours were 8.58 hours (SD ±1.25), and most participants (83.9%) reported working for ≥8 hours per day. Detailed data on the participants' individual and work-related characteristics are presented in Table 1.

In terms of the physical work environment, the average lighting intensity measured at the workstations was 236.25 lx (SD ±169.72), with the majority (81.9%) working under lighting levels below 300 lx. The ambient temperature was relatively high, with a mean of 28.61°C (SD ±1.04), and none of the measured workplaces met the recommended comfortable temperature range of 23–26°C. However, humidity levels were within the ideal range (65–95%) for all respondents, with an average of 70.07% (SD ±3.43).

According to the survey, 65.8% of participants experienced symptoms of asthenopia, with an average score of 0.47 (SD ±0.15). Table 2 provides a comprehensive breakdown of the symptoms related to eye fatigue. The most commonly reported symptoms, rated as occurring "always" or "often," included watery eyes (33.5% always), stinging sensation in the eyes (56.8% always), gritty or sandy feeling (16.1% always), difficulty focusing vision (14.8% always), and heavy sensation in the eyes (17.4% always). Additionally, pain when moving the eyeballs (65.2% often), eyelid twitching (50.3% often), and frequent eye rubbing (50.3% often) were frequently noted.

Spearman's rank correlation was employed to analyze the link between physical environmental factors and symptoms of asthenopia. As presented in Table 3, the findings revealed a statistically significant association between ambient temperature and asthenopia (p = 0.009). In contrast, no significant correlations were found between the lighting intensity (p = 0.799) and humidity (p = 0.742).

Table 1. Distribution of Individual Characteristics, Physical Environmental Factors, and Asthenopia Symptoms (n=155)

Factors	Mean±SD	Median (Min-Max)	f (%)
Individual			
IMT *(kg/m²)*	24.71±2.76	24.6 (17.2-31.9)	
< 18.5			7 (4.5)
18.5-22.9			22 (14.2)
23-24.9			59 (38.1)
25-29.9			66 (42.6)
≥ 30			1 (0.6)
Age *(years old)*	44.36±8.41	46.0 (24.0-66.0)	
20-44			47 (30.3)
45-64			106 (68.4)
≥ 65			2 (1.3)
Years of service *(years)*	13.20±9.94	12,0 (1.0-54.0)	
< 10			54 (34.8)
≥ 10			101 (65.2)
Daily working hours *(hours/day)*	8.58 ± 1.25	8,0 (7.0-14.0)	
< 8			25 (16.1)
≥ 8			130 (83.9)
Physical Environment			
Lighting intensity *(lux)*	236.25±169.72	201.0 (44.30-699.0)	
< 300			127 (81.9)
≥ 300			28 (18.1)
Temperature *(°C)*	28.61±1.04	28.50 (27.20-30.80)	
< 23 atau > 26			155 (100.0)
23 – 26			0 (0.0)
Humidity *(%)*	70.07 ± 3.43	68.0 (67.0-76.0)	
< 65 atau > 95			0 (0.0)
65 – 95			155 (100.0)
Asthenopia symptoms (score)	0.47±0.15	5.0 (0.25-0.9)	
No			53 (34.2)
Yes			102 (65.8)

Table 2. Complaints of eye fatigue (n=155)

Symptoms of Eye Fatigue	Frecuency of Symptoms			
	Never	Occasionally	Often	Always
	f (%)	f (%)	f (%)	f (%)
Pain or throbbing sensation around the eyeballs	96 (61.9)	54 (34.8)	4 (2.6)	1 (0.6)
Eye pain	70 (45.2)	70 (45.2)	14 (9.0)	1 (0.6)
Heavy feeling in the eyes	95 (61.3)	28 (18.1)	5 (3.2)	27 (17.4)
Blurred vision	74 (47.7)	78 (50.3)	2 (1.3)	1 (0.6)
Double or shadowed vision	56 (36.1)	86 (55.5)	10 (6.5)	3 (1.9)
Burning sensation in the eyes	53 (34.2)	88 (56.8)	12 (7.7)	2 (1.3)
Watery eyes	65 (41.9)	37 (23.9)	1 (0.6)	52 (33.5)
Drowsiness	62 (40.0)	52 (33.5)	41 (26.5)	0 (0.0)
Eye strain	50 (32.3)	68 (43.9)	24 (15.5)	13 (8.4)
Dry eyes	74 (47.7)	47 (30.3)	13 (8.4)	21 (13.5)
Itchy eyes	50 (32.3)	38 (24.5)	56 (36.1)	11 (7.1)
Headache	94 (60.6)	27 (17.4)	25 (16.1)	9 (5.8)
Red eyes	90 (581)	37 (23.9)	14 (9.0)	14 (9.0)
Difficulty focusing vision	113 (72.9)	4 (2.6)	15 (9.7)	23 (14.8)
Frequent eye rubbing	48 (31.0)	15 (9.7)	78 (50.3)	14 (9.0)
Glare sensitivity	88 (56.8)	1 (0.6)	41 (26.5)	25 (16.1)
Eyelid twitching or spasms	53 (34.2)	12 (7.7)	78 (50.3)	12 (7.7)
Difficulty closing the eyelids	91 (58.7)	24 (15.5)	16 (10.3)	24 (15.5)
Pain when moving the eyeballs	29 (18.7)	13 (8.4)	101 (65.2)	12 (7.7)
Pain when closing the eyes tightly	114 (73.5)	0 (0.0)	16 (10.3)	25 (16.1)
Stinging sensation in the eyes	53 (34.2)	1 (0.6)	13 (8.4)	88 (56.8)
Gritty feeling in the eyes	117 (75.5)	1 (0.6)	12 (7.7)	25 (16.1)

Table 3. Correlation between Physical Environment and Asthenopia Symptoms

Factors	Asthenopia Symptoms		
	*p**	*rho*	Description
Physical Environment			
Lighting intensity	0.799	0.021	There is no significant correlation***
Temperature	0.009	0.209	There is a significant correlation**
Humidity	0.742	-0.027	There is no significant correlation***

**Spearman's Rank Correlation; **p≤0.05; ***p>0.05*

Discussion

This study aimed to examine the relationship between aspects of the physical work environment and the incidence of asthenopia symptoms among batik artisans in the Klaten Regency. Among the 155 participants, all of whom were women with an average age of 44.36 years, 65.8% reported experiencing eye strain symptoms. These findings indicate that eye strain is a significant occupational health issue for batik artisans, likely attributable to suboptimal working conditions and repetitive tasks.

The study revealed a significant statistical link between ambient temperature and symptoms of asthenopia (p = 0.009). The average temperature in the workplace was 28.61°C, with none of the environments falling within the recommended comfort range of 23–26°C. Extended exposure to higher temperatures can lead to increased tear evaporation and irritation of the ocular surface, resulting in symptoms such as burning, dryness, and watery eyes. This finding is consistent with earlier research indicating that thermal discomfort can worsen visual fatigue, especially during tasks that demand prolonged visual focus.[15,16]

Furthermore, specific studies have highlighted that while heat and humidity levels are crucial factors, personal susceptibility due to physiological and environmental factors also plays a role in determining the impact on health outcomes, including ocular irritation. These conditions necessitate public health interventions and personal strategies to mitigate the adverse effects of extreme temperatures.[17,18] Strategies to combat these effects include maintaining indoor environments within tolerable temperature ranges and ensuring proper hydration and environmental control systems that accommodate for high levels of both heat and humidity. [19]

Conversely, even though a large proportion of participants (81.9%) worked in lighting conditions below 300 lx, which is less than the recommended level for detailed tasks, there was no significant link found between light intensity and asthenopia ($p = 0.799$). This result contrasts with much of the current research, which often points to inadequate lighting as a key factor in visual strain.[20] Various potential confounding factors might have influenced this outcome. To begin with, many batik artisans frequently employ compensatory visual techniques, such as altering the distance between the fabric and their eyes.[21] Additionally, many workers possess extensive experience, which could result in visual adaptation to dim lighting over time.[22] Uncorrected refractive errors, like presbyopia in older workers, might also obscure the independent impact of lighting, as eye strain could occur regardless of luminance quality.[23] Furthermore, visual fatigue in batik production might be more significantly affected by task characteristics, such as motif contrast and the need for fine detail.[24] Collectively, these factors indicate that the connection between illumination and eye strain in informal craft settings is intricate and influenced by multiple interacting elements. Nonetheless, despite the absence of statistical significance, poor lighting still poses a potential risk to long-term visual health and should not be ignored.[20,25]

Recent findings are consistent with previous research associating elevated temperatures with visual discomfort. However, the lack of a significant link between lighting and eye strain differs from most studies conducted in office or screen-intensive environments.[26] This highlights the necessity of considering workplace ergonomics in a more contextual manner, especially in traditional settings like batik production, where tasks and environmental conditions vary from those in industrial or formal sectors. These findings emphasize the importance of improving thermal comfort in traditional batik workplaces to reduce visual discomfort. This could involve enhancing natural or mechanical ventilation and educating artisans on eye health maintenance, such as taking regular breaks, using additional lighting, and possibly wearing protective eyewear, such as full-frame PPE anti-fog protective goggles, vented clear anti-fog goggles, and impact-resistant sealed safety glasses. This type of eyewear offers enhanced protection for the eye surface against heat, dust, and airborne particles typically found in traditional batik production, while also preventing lens fogging, which could increase visual strain.

This study has several limitations. The cross-sectional design limited our ability to establish causal relationships. Asthenopia symptoms were self-reported, which may have introduced recall or perception bias. Moreover, potentially relevant factors such as vision status, use of corrective lenses, and psychosocial stress were not assessed, even though they could influence eye strain outcomes. Future research should employ longitudinal approaches to monitor changes over time and evaluate the effects of such environmental interventions. Utilizing objective instruments, such as lux meters and thermos-hygrometers, along with clinical vision assessments, would improve the understanding of how work environments impact visual health. Examining the role of psychosocial and individual behavioral factors could also provide a more comprehensive understanding of the causes of asthenopia.

Conclusion

This study identified a significant occurrence of asthenopia among batik workers in Klaten, with ambient temperature showing a notable link to symptoms of visual fatigue. While lighting levels were found to be below the standard, neither lighting intensity nor humidity were significantly associated with visual fatigue. These findings underscore the importance of implementing specific ergonomic enhancements in batik home industries, particularly by employing practical heat-control strategies, such as optimizing natural ventilation, installing cost-effective mechanical ventilation, such as exhaust fans, and rearranging workspace layouts to minimize heat exposure.

Furthermore, incorporating regular rest breaks, visual hygiene education, and periodic eye health screenings into community-based occupational health programs is essential for preventing long-term visual issues. Policymakers and local authorities should integrate visual health protection and thermal risk management into batik industry guidelines and small-enterprise empowerment initiatives. Despite the limitations associated with the cross-sectional design and self-reported data, this study provides evidence to support the creation of safer and more sustainable working conditions in the informal craft sector. Future research should include longitudinal designs and objective environmental measurements to enhance our understanding of causality.

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Author Contribution

RSA was responsible for the study design, data collection in the field, and result analysis. CFP interpreted the data, conducted a literature review, and assisted with the preparation and editing of the manuscript. YS supervised the research and made substantial revisions to the manuscript. All the authors have reviewed and approved the final manuscript.

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