Original Article

# Binocular vision parameters in handloom silk weavers

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**ABSTRACT**

**Background:** Focusing the gaze for prolonged periods on a fixed distance demands high visual efficiency in handloom silk weavers and might result in various accommodative and vergence dysfunctions. The aim of the present study was to assess accommodative and vergence parameters and determine the frequency of non-strabismic binocular vision anomalies (NSBVAs) among handloom silk weavers.

**Methods:** In this cross-sectional study, we recruited voluntary handloom silk weavers from the Government-aided Society of Arignar Anna Silk Co-op Society K.H.-1, Kanchipuram, aged 20–39 years. All participants underwent preliminary visual examinations and comprehensive binocular vision testing of accommodative and vergence parameters. Sensory evaluation was performed using stereopsis testing and the Worth 4 Dot test. Motor evaluation included the ocular motility assessment, heterophoria checks for distance and near, near point of convergence, negative and positive fusional vergences for distance and near, vergence facility, negative and positive relative accommodations, both monocular and binocular near points of accommodation, and accommodative facility. The monocular estimate method was used to determine the accommodative response. Quantitative data are expressed as mean (standard deviation [SD]), and qualitative data are expressed as frequency (percentage).

**Results:** We recruited a total of 72 weavers, including 41 (56.9%) men and, 31 (43.1%) women with mean (SD) age, working hours, and work experience of 34.15 (4.12) years, 9 (2.5) h/day, and 17.5 (6.9) years, respectively. Of the 29 (40.3%) weavers with a refractive error, 18 (25%) had astigmatism; seven (9.7%) had myopia; and four (5.6%) had hyperopia. Of the 72 weavers, 38 (52.8%) presented with NSBVAs, including 13 (18.1%) with accommodative dysfunctions, 11 (15.3%) with vergence dysfunctions, and 14 (19.4%) with combined accommodative and vergence dysfunctions. Accommodative insufficiency was the most prevalent dysfunction among all NSBVAs. Overall, 57 (79.2%) handloom silk weavers reported vision-related symptoms during their weaving hours, all with NSBVAs (n = 38), 19 with normal parameters in the binocular vision test, and 15 with no symptoms.

**Conclusions:** The frequency of NSBVAs was high among handloom silk weavers compared to the literature. This implies a need for comprehensive binocular vision examination for people in this occupation to rule out NSBVAs for improving their quality of life and occupational productivity. Future large-scale studies are required to determine the exact NSBVAs prevalence among workers of this near vision-related occupation.

**KEYWORDS**

occupation, worker, binocular vision, ocular accommodation, ocular convergence, frequency, prevalence

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## INTRODUCTION

Handloom weaving is a textile production method used to weave fabrics without the use of electricity. Kanchipuram is one of the main districts that produce a large number of mulberry silk sarees [1]. Handloom weaving involves the process of taking yarn and fashioning it into fabric. Traditionally, the process of weaving a silk saree starts with thread dyeing, hand spinning, bobbin winding, warping, street sizing, attaching the warp onto the loom, weft winding, and finally, weaving in the handloom, which are all performed by the weavers [2].

Almost all of these processes for weavers involve minute visual tasks at a closer working distance. The weaving process is a lengthy and tiring procedure. Typically, it takes approximately 30 days to weave a complete saree [1]. Performing near and intermediate visual tasks for an extended period can increase visual demand and cause eye strain [3]. This prolonged near work may result in binocular vision anomalies [4, 5].

Binocular vision anomalies are classified into *strabismic* or *non-strabismic* binocular vision anomalies (NSBVAs). Strabismic binocular vision anomalies are associated with congenital or acquired strabismus, whereas NSBVAs consist of accommodative and vergence dysfunctions [6, 7]. NSBVAs is more prevalent among the population who spend more time performing near work [8]. Focusing the eyes at a fixed distance for prolonged periods demands high visual efficiency that may result in various accommodative and vergence dysfunctions [9].

Because of these important factors, this study aimed to assess binocular vision function and accommodation and vergence parameters of handloom silk weavers. Furthermore, we determined the frequency of NSBVAs among this population.

## METHODS

This cross-sectional study was approved by the Institutional Review Board of Sri Ramachandra Institute of Higher Education and Research, Porur, Chennai, India, and adhered to the tenets of the Declaration of Helsinki. Written informed consent was provided by each participant in the study. Willing handloom silk weavers aged 20 to 39 years were recruited from the government-aided Kanchipuram Arignar Anna Silk Co-Op Society K.H.1, Kanchipuram, Tamil Nadu, India. Participants were selected based on the inclusion criteria, and a complete orthoptic evaluation was performed on each individual to assess binocular vision functions.

Demographic data, chief ocular complaints, ocular history, medical history, and detailed work-related symptoms such as headaches, sleepiness, eye pain, watering, burning sensation, eyestrain, visual discomfort, ocular surface discomfort, double vision, problems refocusing between viewing distances, blurring of vision, working hours, and work experience were obtained by taking a complete history.

Best-corrected distance visual acuity was examined using the Snellen E chart, and near vision was examined using the Jaeger near-vision card. Individuals with a best-corrected visual acuity better than or equal to 20/30 at distance and N5 at near, with or without refractive errors, and without amblyopia or strabismus, were considered eligible. Pupillary examinations were performed to identify pupillary abnormalities [10], the cover test was performed to identify any manifest deviation for distance and near, and heterophoria was measured [11]. The anterior and posterior segments were examined using both a torch light and a direct ophthalmoscope (ref. 11720-BI; Welch Allyn, Auburn, NY, USA).

Refraction was performed using static retinoscopy (Welch Allyn) and was subjectively refined. Any type of refractive error was recorded. If the weaver needed only refractive correction, glasses were prescribed with instructions to wear them for two weeks. Complete binocular vision evaluation was then performed with vision correction two weeks after the administration of refractive correction.

A total of 72 eligible voluntary weavers underwent a complete binocular vision assessment, including sensory and motor evaluation [12-14]. In the sensory evaluation, stereopsis testing (Titmus fly test, Stereo Optical Co., Inc., Chicago, IL, USA) [15] and the Worth's Four Dot test [16] were performed. In motor evaluation, ocular motility was assessed using the broad-H test [17], and a modified Thorington test using the Bernell Muscle Imbalance Measure card [18] was performed to determine the presence of heterophoria for distance and near; the near point of convergence was assessed using red and green filters [19]. Negative (divergence) and positive (convergence) fusional vergence were measured using a hand-held prism bar for both distance and near [20], and vergence facility was measured using the flipper prism with 12 prism base-out and 3 prism base-in [21]. Negative and positive relative accommodation were also measured [22]. Both monocular and binocular near point of accommodation and accommodative facility using ± 2.00 D flipper lenses were measured. The monocular estimate method was used to determine accommodative response [23-25].

The results of vergence and accommodative tests were compared with age-matched normative data for binocular vision parameters [12, 26, 27]. The findings were then grouped based on their deviation from the

normal values, and anomalies were ruled out based on the diagnostic criteria. Finally, individuals with abnormal signs based on the binocular vision assessment, with or without eye symptoms during their weaving hours, were considered to have NSBVAs [12].

The collected data were analyzed using IBM SPSS Statistics software for Windows (version 23.0; IBM Corp., Armonk, NY, USA), and descriptive statistics are reported. Quantitative data are expressed as mean (standard deviation [SD]), and qualitative data are expressed as frequency (percentage).

## RESULTS

A total of 72 handloom silk weavers aged 20 to 39 years were included in this study. The group comprised 41 men (56.9%) and 31 women (43.1%). The mean (SD) age, working hours, and work experience were 34.15 (4.12) years, 9 (2.5) hours per day, and 17.5 (6.9) years, respectively. There were 29 (40.3%) weavers with refractive errors, and 43 (59.7%) were emmetropes. Among the 29 individuals with refractive errors, 18 (25%) had astigmatism, 7 (9.7%) had myopia, and 4 (5.6%) had hyperopia. Tables 1 and 2 show the mean (SD) values for the accommodative and vergence function parameters, respectively.

**Table 1. Mean values of accommodative functions in study participants**

| Accommodation tests | | Mean ± SD |
|---|---|---|
| NPA (D) | OD | 15.61 ± 5.53 |
| | OS | 15.66 ±5.56 |
| | OU | 15.54 ± 5.49 |
| NRA (D) | | 2.32 ± 0.41 |
| PRA (D) | | 1.68 ± 0.77 |
| AF (CPM) | OD | 4.34 ± 3.55 |
| | OS | 4.24 ± 3.50 |
| | OU | 3.36 ± 2.64 |
| MEM (D) | OD | 0.94 ± 0.52 |
| | OS | 0.92 ± 0.52 |

**Abbreviations: SD, standard deviation; NPA, near point of accommodation; D, Diopters; OD, right eye; OS, left eye; OU, both eyes; NRA, negative relative accommodation; PRA, positive relative accommodation; AF, accommodative facility; CPM, cycle per minute; MEM, monocular estimation method.**

**Table 2. Mean values of vergence functions in study participants**

| Vergence Tests | | Mean ± SD |
|---|---|---|
| NPC (cm) | Break | 12.33 ± 6.69 |
| | Recovery | 15.45 ± 7.75 |
| Distance NFV (PD) | Break | 7.05 ± 2.07 |
| | Recovery | 4.13 ± 1.79 |
| Near NFV (PD) | Blur | 1.21 ± 3.30 |
| | Break | 11.82 ± 4.70 |
| | Recovery | 8.47 ± 4.54 |
| Distance PFV (PD) | Blur | 2.79 ± 5.17 |
| | Break | 14.68 ± 4.92 |
| | Recovery | 11.37 ± 4.05 |
| Near PFV (PD) | Blur | 3.94 ± 6.37 |
| | Break | 15.42 ± 5.51 |
| | Recovery | 11.76 ± 5.12 |
| VF (CPM) | | 9.63 ± 3.54 |

**Abbreviations: SD, standard deviation; NPC, near point of convergence; cm, centimeter; NFV, negative fusional vergence; PD, prism diopters; PFV, positive fusional vergence; VF, vergence facility; CPM, cycle per minute.**

**Table 3. Frequency of non-strabismic binocular vision anomalies (NSBVAs) among study participants**

| Dysfunctions | n (%) |
|---|---|
| **Accommodative dysfunctions** | **13 (18.1)** |
| Accommodative insufficiency | 7 (9.7) |
| Accommodative infacility | 4 (5.6) |
| Accommodative excess | 2 (2.8) |
| **Vergence dysfunctions** | **11 (15.3)** |
| Convergence excess | 7 (9.7) |
| Divergence insufficiency | 4 (5.6) |
| **Combined accommodative and vergence dysfunctions** | **14 (19.4)** |
| Accommodative insufficiency with convergence insufficiency | 7 (9.7) |
| Ill-sustained accommodation with convergence insufficiency | 4 (5.6) |
| Convergence insufficiency with accommodative excess | 2 (2.8) |
| Accommodative insufficiency with convergence excess | 1 (1.3) |
| **Total** | **38 (52.8)** |

**Abbreviations: n, number of participants; %, percentage.**

**Table 4. Frequency of symptomatic versus asymptomatic participants**

| Status | NSBVAs, n (%) | Normal BV, n (%) | Total, n (%) |
|---|---|---|---|
| **Symptomatic** | 38 (52.8) | 19 (26.4) | 57 (79.2) |
| **Asymptomatic** | 0 (0.0) | 15 (20.8) | 15 (20.8) |
| **Total** | 38 (52.8) | 34 (47.2) | 72 (100.0) |

**Abbreviations: NSBVAs, non-strabismic binocular vision anomalies; n, number of participants; %, percentage; BV, binocular vision.**

The results of the vergence and accommodative tests were compared with the age-matched normative data of binocular vision parameters. The findings were then grouped based on their deviation from the normal values, and anomalies were ruled out based on the diagnostic criteria. The criteria and cut-off values for NSBVAs diagnosis were based on those of Scheiman and Wick [12].

Table 3 shows the frequency of NSBVAs among the 72 handloom silk weavers. Of the 72 weavers, 38 (52.8%) presented with NSBVAs. Of these, 13 (18.1%) had accommodative dysfunction, 11 (15.3%) had vergence dysfunction, and 14 (19.4%) had both accommodation and vergence dysfunction. Accommodative insufficiency was the most prevalent dysfunction, with or without a combination of vergence dysfunctions. Thirty-four weavers (47.2%) had normal binocular vision (Table 4).

Overall, 57 (79.2%) participants reported vision-related symptoms during weaving hours. All participants with NSBVAs were symptomatic during weaving time. However, among the participants with normal parameters of binocular vision testing, 19 (26.4%) were symptomatic, while 15 (20.8%) were asymptomatic (Table 4).

## DISCUSSION

Of the 72 handloom silk weavers, 38 (52.8%) had accommodative and/or vergence dysfunction, with a higher rate of combined dysfunctions (19.4%). The frequency of NSBVAs among our participants was higher compared to that of published papers [7, 28, 29]. The most prevalent of the combined accommodative and vergence dysfunctions was accommodative insufficiency with convergence insufficiency (9.7%). This frequency is similar to that of other studies that also found accommodative insufficiency with convergence insufficiency in their population [30-32].

In our study, we found ill-sustained accommodation with convergence insufficiency in 5.6% of participants. Most authors have described ill-sustained accommodation as an early stage of accommodative insufficiency and categorized it as a sub-classification of accommodative insufficiency [33, 34]. We also observed combined dysfunctions such as convergence insufficiency with accommodative excess (2.8%) and accommodative insufficiency with convergence excess (1.3%). This finding is consistent with those of other studies [30-32, 35].

Of the vergence dysfunctions (15.3%), 9.7% were convergence excesses, which correlates with the findings of Lara et al. [30], Garcia-Munoz et al. [32], and Montes-Mico [36], who found convergence excesses of 9%, 2.29%, and 1.5%, respectively. The finding of divergence insufficiency in 5.6% agrees with the findings of Paniccia et al. [28] and Montes-Mico [36], who found divergence insufficiencies of 2.7% and 2.1%, respectively.

Of our participants, 18.1% had accommodative dysfunction, 9.7% had accommodative insufficiency, 5.6% had accommodative infacility, and 2.8% had accommodative excess. Among the participants with NSBVAs (52.8%), accommodative insufficiency was the most common dysfunction both for those with only accommodative dysfunction and for those who had vergence dysfunction (convergence insufficiency and convergence excess). The prevalence of accommodative insufficiency in this occupational sector agrees with that reported by Montes-Mico [36].

NSBVA is associated with certain symptoms. In this study, all 38 individuals with NSBVAs presented with visual symptoms. Nineteen individuals also presented with work-related visual symptoms but had normal binocular vision. The most important symptoms, such as headaches, blurred vision, eyestrain, eye pain, sleepiness, watering, and burning sensation, were reported by our participants during their working hours. Similar symptoms have been reported in binocular vision dysfunction, such as convergence and accommodative insufficiency [37, 38]. Durlov et al. [39] observed that the weaving job also involves many occupational risk factors such as awkward sitting postures, high force, repetitive movement, long duration of work, and high visual demand. Therefore, any visual symptoms could affect an individual's working performance and may increase the level of work strain.

To our knowledge, the findings of this study provide the first evidence of the visual efficiency of handloom silk weavers. Occupations with excessive near workloads can induce NSBVAs. This may have a significant impact on occupational productivity, apart from visual comfort, as 79.2% of handloom silk weavers experienced visual symptoms during their weaving hours. The study was limited by a lack of long-term follow-up or assessment of the effectiveness of appropriate interventions, a small number of participants, and recruitment of participants from a single center. Future large-scale studies are needed to determine the exact prevalence of NSBVAs among workers in this near-work-related occupation.

## CONCLUSIONS

As a significant number of handloom silk weavers develop NSBVAs, early detection and treatment of this condition are important to improve the worker's quality of life and occupational productivity. Eye care professionals must investigate occupations with high visual demand and provide awareness about eye health. Hence, we recommend comprehensive binocular vision examination for this type of occupation to rule out NSBVAs.

## ETHICAL DECLARATIONS

**Ethical approval:** This cross-sectional study was approved by the Institutional Review Board of Sri Ramachandra Institute of Higher Education and Research, Porur, Chennai, India, and adhered to the tenets of the Declaration of Helsinki. Written informed consent was provided by each participant in the study.
**Conflict of interests:** None

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