

*Original Article*

# Effect of Rhythmic Near-Task Reading on Convergence Recovery in Madrasa Students

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## ABSTRACT

**Background:** Madrasa students are frequently exposed to prolonged near-task reading and recitation, often accompanied by habitual rhythmic forward-backward swaying. Although near work, posture, and visual symptoms have been studied in school-aged populations, limited evidence is available regarding the association between rhythmic swaying and convergence recovery in madrasa students. **Objective:** To assess the association between rhythmic swaying during near-task reading and convergence recovery among madrasa students. **Methods:** This cross-sectional observational study was conducted at Madrasa Rehmat-ul-Alameen, Lahore, from December 2025 to March 2026. A total of 359 male students aged 8–18 years were included through convenience sampling. Visual acuity screening and basic ocular examination were performed, and reading posture, near-work duration, rhythmic swaying, and convergence recovery were assessed. Near point of convergence recovery was measured in centimeters using a RAF ruler. Associations were analyzed using Chi-square testing and independent-samples t-test. **Results:** Rhythmic swaying was observed in 238 students (66.3%), while 121 students (33.7%) showed no swaying. Students with swaying had significantly poorer mean convergence recovery than non-swaying students ( $11.82 \pm 3.18$  cm vs.  $8.96 \pm 2.76$  cm; mean difference 2.86 cm;  $p < 0.001$ ). Impaired convergence recovery was more frequent among swaying students than non-swaying students (58.8% vs. 28.1%; OR = 3.66, 95% CI: 2.28–5.87;  $p < 0.001$ ). Swaying prevalence increased progressively from upright posture (37.2%) to severe neck bending (96.2%). **Conclusion:** Rhythmic swaying during near-task reading was significantly associated with impaired convergence recovery among madrasa students. Screening for convergence recovery and reading posture may help identify students at risk of binocular vision dysfunction. **Keywords:** Convergence Recovery; Rhythmic Swaying; Near Work; Madrasa Students; Reading Posture; Binocular Vision.

## INTRODUCTION

Visual problems among children and adolescents remain an important public health concern because they may interfere with reading efficiency, classroom performance, concentration, and overall learning capacity. In madrasa settings, students are commonly exposed to prolonged periods of near-task reading and recitation, often from an early age, which may increase visual demand and contribute to symptoms of ocular fatigue, visual discomfort, and reduced binocular efficiency. Studies conducted among madrasa and school-aged populations in Pakistan and comparable regional settings have reported a meaningful burden of refractive errors and ocular morbidity, indicating the need for targeted visual health assessment in educational environments where sustained near work is a major component of daily activity (1–4).

Near-task reading requires coordinated interaction between accommodation and vergence systems to maintain clear and single binocular vision. Convergence is the inward movement of both eyes during near fixation, while convergence recovery reflects the ability of the vergence system to regain binocular alignment after convergence demand has been disrupted. Impairment in convergence function may lead to asthenopic symptoms such as eyestrain, headache, intermittent blur, diplopia, and reduced reading

endurance. These symptoms are clinically relevant in students because visual discomfort during sustained reading can affect attention and learning performance. Previous literature has shown that near-work exposure, reading posture, visual environment, and prolonged accommodative-vergence demand may influence visual comfort and binocular function in children and young adults (5–10).

Madrassa students represent a distinct educational population because their learning activities often involve long-duration reading, memorization, and recitation at close working distances. In addition to prolonged near work, many students demonstrate rhythmic forward-backward swaying movements during reading. This behavior is culturally and habitually observed in some madrasa environments but has received limited scientific attention in relation to binocular vision. Rhythmic swaying may alter head and neck posture during near fixation, and sustained or repetitive cervical movement may plausibly influence ocular motor control through proprioceptive input from the neck. Evidence from ocular motor and proprioceptive research suggests that cervical afferent input can affect eye position control and gaze stability, which provides a biologically plausible basis for investigating whether habitual swaying during near-task reading is associated with altered convergence recovery (11).

Although refractive error and asthenopic symptoms have been studied among school and madrasa students, convergence recovery in relation to habitual rhythmic swaying remains insufficiently explored. Most available work focuses on refractive status, myopia-related risk factors, or general visual symptoms, while fewer studies examine specific vergence parameters in students exposed to prolonged recitation-based near work. This creates a knowledge gap regarding whether rhythmic reading-related body movement is associated with measurable differences in convergence recovery among madrasa students. Addressing this gap is important because convergence recovery assessment may identify binocular vision dysfunction that is not detected by visual acuity screening alone.

Therefore, the present study was designed to assess the association between rhythmic swaying during near-task reading and convergence recovery among madrasa students aged 8–18 years. The primary objective was to compare convergence recovery between students with and without rhythmic swaying behavior during routine reading. The secondary objective was to examine whether reading posture and swaying severity were associated with impaired convergence recovery. The study hypothesized that students demonstrating rhythmic swaying during near-task reading would have poorer convergence recovery than students who did not demonstrate swaying behavior.

## MATERIALS AND METHODS

This cross-sectional observational study was conducted at Madrasa Rehmat-ul-Alameen, Lahore, Pakistan, from December 2025 to March 2025. The study was designed to assess the association between rhythmic swaying during habitual near-task reading and convergence recovery among madrasa students in their natural educational environment. Data collection was performed during routine madrasa reading and recitation activities to ensure that posture, reading distance, and swaying behavior reflected usual study conditions rather than an artificially controlled laboratory setting.

A total of 359 madrasa students aged 8–18 years were included through convenience sampling. Students were eligible if they had been enrolled in the madrasa for at least one year and were actively engaged in routine near-task reading or recitation. Rhythmic swaying was not used as an inclusion criterion; instead, it was assessed as the main exposure variable so that students with and without swaying behavior could be compared. Students were excluded if they had diagnosed ocular pathology other than refractive error, manifest strabismus, history of ocular surgery, known neurological or systemic disease affecting ocular motor function, or current use of medication known to influence accommodation or vergence. Ethical approval was obtained before data collection, and informed consent was taken from parents or guardians before participation.

Initial ocular screening included assessment of distance visual acuity using a Snellen chart and LogMAR visual acuity chart, followed by basic anterior segment and ocular health examination using a pen torch. The screening was performed to identify eligibility and exclude students with obvious ocular abnormalities that could affect convergence assessment. Demographic information and study-related variables were collected using a structured questionnaire. Recorded variables included age, duration of madrasa education, daily near-work duration, habitual reading posture, reading distance, presence and severity of rhythmic swaying, asthenopic symptoms, and convergence parameters.

Reading posture was observed during routine near-task reading and categorized according to the degree of neck flexion as upright posture, mild neck bending, moderate neck bending, or severe neck bending. Reading distance was measured during the student's habitual reading posture. Rhythmic swaying during reading was assessed through direct observation and classified according to observed movement frequency as none, mild, moderate, or severe. Mild swaying was defined as 1–5 forward-backward movements per minute, moderate swaying as 6–10 movements per minute, and severe swaying as more than 10 movements per minute. For comparative analysis, swaying was also categorized as a binary exposure variable, with students classified as either having rhythmic swaying or no rhythmic swaying.

Convergence function was assessed using a RAF ruler with an accommodative target under standardized near-viewing conditions. The near point of convergence was measured by gradually moving the target toward the participant along the ruler until the participant reported diplopia or the examiner observed loss of binocular fixation, which was recorded as the break point. The target was then moved away until the participant regained single binocular vision, which was recorded as the recovery point. Convergence recovery was measured in centimeters, with higher recovery values indicating poorer recovery efficiency. Impaired convergence recovery was operationally defined according to the cutoff applied during analysis, and all recovery measurements were documented by the examiner for statistical evaluation. To reduce measurement variability, the same measurement procedure was used for all participants, and testing was performed in the madrasa setting under comparable reading conditions.

The primary outcome variable was convergence recovery distance measured in centimeters. The main exposure variable was rhythmic swaying during near-task reading. Secondary variables included swaying severity, reading posture, reading distance, near-work duration, age group, and asthenopic symptoms. Potential confounding was addressed at the design and analysis stages by applying predefined eligibility criteria, excluding students with ocular or neurological conditions likely to affect vergence, recording relevant near-work and postural variables, and comparing convergence recovery across exposure categories. Reading posture, near-work duration, and age were considered clinically relevant covariates because each could plausibly influence convergence function or visual fatigue.

The sample size consisted of 359 eligible participants assessed during the study period. This sample was considered sufficient for estimating the association between rhythmic swaying and convergence recovery in the selected madrasa population and for conducting subgroup comparisons across swaying and posture categories. Data were entered and analyzed using SPSS version 31.0. Descriptive statistics were calculated for demographic, exposure, and clinical variables. Frequencies and percentages were used for categorical variables, while means and standard deviations were used for continuous variables. The Chi-square test was used to assess associations between categorical variables, including swaying status, posture category, and impaired convergence recovery. Independent-samples t-test was used to compare mean convergence recovery between students with and without rhythmic swaying. Analysis of variance was planned for comparison of convergence recovery across more than two exposure categories, including swaying severity and near-work duration groups. Pearson correlation analysis was used to examine relationships among near-work duration, swaying frequency, and convergence parameters where variables met assumptions for correlation analysis. A p-value of less than 0.05 was considered statistically significant.

To strengthen reproducibility and data integrity, all measurements were recorded on structured data collection forms and entered into the statistical software using predefined variable categories. Participant eligibility was assessed before convergence testing, and the same operational definitions were applied throughout data collection. Incomplete or inconsistent entries were checked against original data forms before analysis. Findings were reported using group-specific denominators so that comparisons between swaying and non-swaying students, and between posture categories, could be interpreted transparently.

## RESULTS

The final analysis included 359 madrasa students aged 8–18 years. All participants were male. The largest age group was 11–13 years, comprising 120 students (33.4%), followed by 14–16 years with 95 students (26.5%), 8–10 years with 85 students (23.7%), and 17–18 years with 59 students (16.4%). Rhythmic swaying during near-task reading was observed in 238 students (66.3%), while 121 students (33.7%) did not demonstrate swaying behavior. Nearly half of the participants, 173 students (48.2%), reported more than 4 hours of daily near work, while 86 students (24.0%) reported 3–4 hours and 100 students (27.9%) reported 1–2 hours of near work per day. Reading posture varied across the sample, with moderate neck bending being the most frequent posture category, observed in 117 students (32.6%), followed by mild neck bending in 112 students (31.2%), upright posture in 78 students (21.7%), and severe neck bending in 52 students (14.5%).

*Table 1. Demographic and Near-Work Characteristics of Madrasa Students*

Variable	Category	n	%
Total sample	—	359	100.0
Sex	Male	359	100.0
Age group	8–10 years	85	23.7
	11–13 years	120	33.4
	14–16 years	95	26.5
	17–18 years	59	16.4
Rhythmic swaying during reading	Yes	238	66.3
	No	121	33.7
Daily near-work duration	1–2 hours	100	27.9
	3–4 hours	86	24.0
	>4 hours	173	48.2
Reading posture	Upright posture	78	21.7
	Mild neck bending	112	31.2
	Moderate neck bending	117	32.6
	Severe neck bending	52	14.5

Reading posture showed a statistically significant association with rhythmic swaying during near-task reading. The proportion of students demonstrating swaying increased progressively with greater neck flexion, rising from 29 of 78 students (37.2%) in the upright posture group to 66 of 112 students (58.9%) among those with mild neck bending, 93 of 117 students (79.5%) among those with moderate neck bending, and 50 of 52 students (96.2%) among those with severe neck bending. The association was statistically significant, with  $\chi^2 = 62.172$ ,  $df = 3$ , and  $p < 0.001$ . The effect size was moderate to strong, as indicated by Cramer's  $V = 0.416$ , suggesting that worsening reading posture was meaningfully associated with a higher likelihood of rhythmic swaying.

*Table 2. Association Between Reading Posture and Rhythmic Swaying During Near-Task Reading*

Reading posture	Total n	Swaying n (%)	No swaying n (%)	$\chi^2$	df	p-value	Effect size
Upright posture	78	29 (37.2)	49 (62.8)	62.172	3	<0.001	Cramer's V = 0.416
Mild neck bending	112	66 (58.9)	46 (41.1)				
Moderate neck bending	117	93 (79.5)	24 (20.5)				
Severe neck bending	52	50 (96.2)	2 (3.8)				
Total	359	238 (66.3)	121 (33.7)				

Students who demonstrated rhythmic swaying had significantly poorer convergence recovery than those who did not demonstrate swaying. The mean convergence recovery distance was  $11.82 \pm 3.18$  cm in the

swaying group compared with  $8.96 \pm 2.76$  cm in the non-swaying group. The mean difference between groups was 2.86 cm, with a 95% confidence interval of 2.22 to 3.50 cm. This difference was statistically significant using Welch's independent-samples t-test, with  $t = 8.808$ ,  $df = 273.548$ , and  $p < 0.001$ . The standardized effect size was large (Cohen's  $d = 0.94$ ), indicating that the difference in convergence recovery between swaying and non-swaying students was not only statistically significant but also clinically meaningful.

**Table 3. Comparison of Convergence Recovery According to Rhythmic Swaying Status**

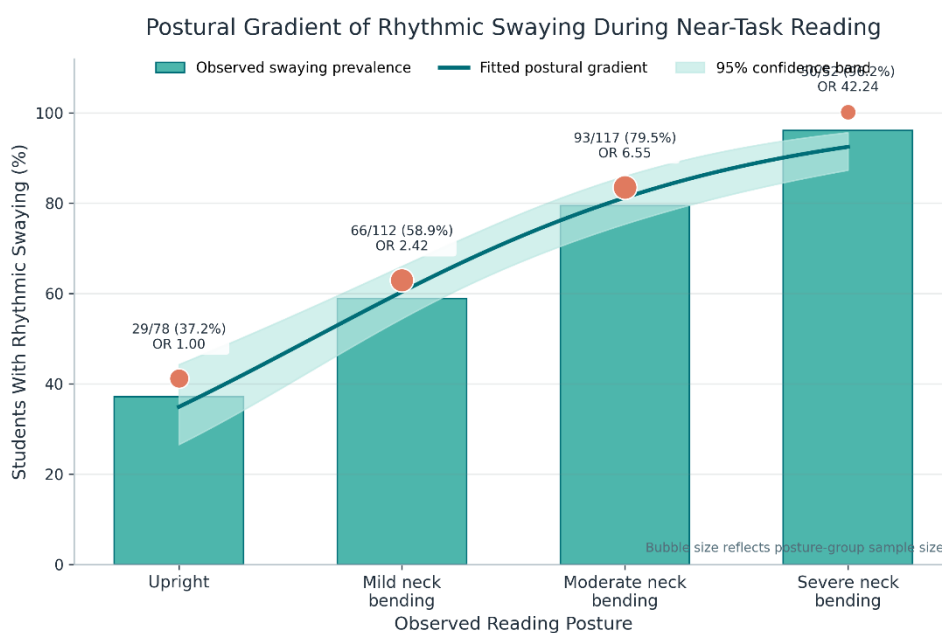
Rhythmic swaying	n	Mean convergence recovery (cm)	Standard deviation	Mean difference (cm)	95% CI for mean difference	t-value	df	p-value	Effect size
Yes	238	11.82	3.18	2.86	2.22 to 3.50	8.808	273.548	<0.001	Cohen's $d = 0.94$
No	121	8.96	2.76						

Impaired convergence recovery was more frequent among students with rhythmic swaying than among those without swaying. Among students who demonstrated swaying, 140 of 238 students (58.8%) had impaired convergence recovery, compared with 34 of 121 students (28.1%) in the non-swaying group. Overall, impaired convergence recovery was present in 174 of 359 students (48.5%).

**Table 4. Association Between Rhythmic Swaying and Impaired Convergence Recovery**

Rhythmic swaying	Total n	Impaired convergence recovery n (%)	Normal convergence recovery n (%)	$\chi^2$	df	p-value	Odds ratio	95% CI for OR	Relative risk	95% CI for RR
Yes	238	140 (58.8)	98 (41.2)	30.318	1	<0.001	3.66	2.28 to 5.87	2.09	1.54 to 2.84
No	121	34 (28.1)	87 (71.9)							
Total	359	174 (48.5)	185 (51.5)							

The association between rhythmic swaying and impaired convergence recovery was statistically significant, with  $\chi^2 = 30.318$ ,  $df = 1$ , and  $p < 0.001$ . Students with rhythmic swaying had approximately 3.66 times higher odds of impaired convergence recovery than students without swaying (OR = 3.66, 95% CI: 2.28 to 5.87). The relative risk was also elevated, with impaired recovery being approximately 2.09 times more common in the swaying group than in the non-swaying group (RR = 2.09, 95% CI: 1.54 to 2.84).



**Figure 1 Postural Gradient of Rhythmic Swaying During Near-Task Reading**

Rhythmic swaying increased progressively with greater neck flexion during near-task reading, rising from 37.2% in students with upright posture (29/78) to 58.9% with mild neck bending (66/112), 79.5% with moderate neck bending (93/117), and 96.2% with severe neck bending (50/52). Compared with

upright posture, the odds of rhythmic swaying were 2.42 times higher with mild neck bending, 6.55 times higher with moderate neck bending, and 42.24 times higher with severe neck bending, demonstrating a strong postural exposure gradient. This pattern supports the clinical relevance of reading posture as a marker of habitual rhythmic movement during prolonged near-task reading and strengthens the rationale for incorporating postural assessment into binocular-vision screening among madrasa students.

Overall, the results demonstrate a consistent pattern in which rhythmic swaying during near-task reading was associated with poorer convergence recovery among madrasa students. The association was evident both as a continuous outcome, where swaying students had a mean recovery distance 2.86 cm higher than non-swaying students, and as a categorical outcome, where impaired recovery was observed in 58.8% of swaying students compared with 28.1% of non-swaying students. Reading posture also showed a graded relationship with swaying behavior, with swaying prevalence increasing from 37.2% in upright posture to 96.2% in severe neck bending. These findings suggest that habitual rhythmic swaying and postural strain during prolonged near-task reading may be clinically relevant markers for reduced binocular recovery efficiency in madrasa students.

## DISCUSSION

The present study found a significant association between rhythmic swaying during near-task reading and impaired convergence recovery among madrasa students. Students who demonstrated rhythmic swaying had a higher mean convergence recovery distance than students without swaying, indicating poorer recovery efficiency after near-point convergence demand. The difference was statistically and clinically meaningful, with the swaying group showing a mean recovery distance of  $11.82 \pm 3.18$  cm compared with  $8.96 \pm 2.76$  cm in the non-swaying group, corresponding to a mean difference of 2.86 cm and a large standardized effect size. Impaired convergence recovery was also substantially more frequent among students with rhythmic swaying, affecting 140 of 238 students (58.8%), compared with 34 of 121 students (28.1%) without swaying. Overall, impaired convergence recovery was identified in 174 of 359 students (48.5%), suggesting that reduced binocular recovery efficiency may be common in this near-work-intensive educational population.

The observed findings are clinically relevant because convergence recovery reflects the ability of the binocular visual system to regain single vision after sustained near fixation. Poor recovery may contribute to visual fatigue, eyestrain, headache, intermittent blur, reading discomfort, and reduced concentration during prolonged near tasks. Previous work has shown that near-work exposure, sustained accommodative demand, and visual discomfort are associated with ocular symptoms in students and young adults, particularly where prolonged reading or screen-based activity is common (12–14). The present findings extend this concern to madrasa students, whose academic routine involves prolonged recitation and memorization at near distances. Although visual acuity screening can identify refractive impairment, it may not detect vergence-related dysfunction; therefore, convergence recovery assessment may provide additional value in screening students with persistent symptoms during reading.

A strong graded association was also observed between reading posture and rhythmic swaying. Swaying prevalence increased from 37.2% among students with upright posture to 58.9% with mild neck bending, 79.5% with moderate neck bending, and 96.2% with severe neck bending. This trend suggests that rhythmic swaying is not an isolated behavioral feature but may be linked with habitual postural adaptation during sustained near-task reading. The increasing odds of swaying across posture categories support the possibility that neck flexion, reading distance, and repetitive movement may interact during prolonged study sessions. Previous studies have reported associations between reading posture, near-work behavior, and visual strain, particularly in students exposed to prolonged close work (15,16). The present results are consistent with this broader evidence and suggest that posture should be considered when assessing binocular vision in educational settings with extended reading demands.

The possible mechanism underlying the association between rhythmic swaying and poorer convergence recovery may involve interaction between cervical posture, proprioceptive input, and ocular motor control. Repetitive forward-backward head and trunk movement during reading may alter the stability of near fixation and increase the demand on the vergence system. Cervical proprioceptive input has been described as an important contributor to gaze control and eye movement coordination, and altered neck posture or movement may influence ocular motor stability (17). In the context of madrasa reading, repeated swaying combined with sustained convergence demand may therefore place additional stress on the vergence recovery mechanism. However, this explanation should be interpreted cautiously because the present study was observational and cannot establish a direct causal pathway.

The findings also have practical implications for madrasa-based visual health screening. Students with rhythmic swaying, severe neck bending, prolonged near work, or visual symptoms may benefit from targeted binocular vision assessment in addition to routine visual acuity testing. Screening protocols in such settings should include near point of convergence, convergence recovery, reading distance, posture observation, and symptom assessment. Early detection of poor convergence recovery may help identify students who require referral for comprehensive optometric evaluation, vision therapy assessment, refractive correction, or ergonomic guidance. Existing evidence supports the importance of diagnosing and managing convergence insufficiency and related binocular vision problems in school-aged populations because untreated symptoms may interfere with reading comfort and academic performance (18–22).

The study has several limitations. First, the cross-sectional design prevents causal inference, so rhythmic swaying should be interpreted as being associated with impaired convergence recovery rather than as a proven cause. Second, convenience sampling from a single madrasa limits generalizability to other madrasa systems, school settings, female students, or different age groups. Third, although swaying frequency and posture were observed during routine reading, observer-based classification may introduce measurement bias if inter-rater reliability is not assessed. Fourth, potential confounders such as refractive status, lighting, reading distance, near-work duration, sleep, fatigue, and asthenopic symptoms may influence convergence recovery and should ideally be adjusted using multivariable regression in future analyses. Fifth, the absence of longitudinal follow-up means that the persistence or progression of convergence recovery impairment cannot be determined.

Despite these limitations, the study contributes useful preliminary evidence on a neglected visual health issue in madrasa students. The consistent pattern across continuous and categorical recovery outcomes strengthens the observation that rhythmic swaying is associated with poorer convergence recovery. The graded relationship between neck bending and swaying further suggests that posture and habitual reading behavior may be important contextual factors in binocular vision assessment. Future studies should use multicenter sampling, include both male and female students, apply standardized repeated NPC measurements, incorporate refractive and asthenopic symptom data, and use adjusted statistical models to determine whether swaying remains independently associated with convergence recovery after controlling for major confounders.

## CONCLUSION

Rhythmic swaying during near-task reading was significantly associated with impaired convergence recovery among madrasa students. Students with swaying demonstrated poorer mean convergence recovery than those without swaying, with recovery distances of  $11.82 \pm 3.18$  cm and  $8.96 \pm 2.76$  cm, respectively, and impaired recovery was more frequent in the swaying group (58.8%) than in the non-swaying group (28.1%). Reading posture also showed a strong graded association with swaying, increasing from 37.2% in upright posture to 96.2% in severe neck bending. These findings suggest that rhythmic movement and postural strain during prolonged near-task reading may serve as clinically relevant markers of reduced binocular recovery efficiency. Routine screening for convergence recovery,

reading posture, near-work behavior, and asthenopic symptoms should be considered in madrasa settings, while longitudinal and interventional studies are needed to clarify causality and evaluate preventive strategies.

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