Original Article

DOI: 10.7860/JCDR/2026/87830.23608

Physiotherapy Section

Correlation between Forward Head Posture, Reaction Time and Eye-hand Coordination among College-going Students: A Cross-sectional Study

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ABSTRACT

Introduction: Forward Head Posture (FHP) is prevalent among college students, potentially impairing sensorimotor function via disrupted proprioceptive feedback, though evidence in asymptomatic populations remains limited.

Aim: To investigate correlations between Craniovertebral Angle (CVA), eye-hand coordination Alternate Hand Wall Toss Test (AHWTT) and reaction time {Ruler Drop Test (RDT)} in asymptomatic students with FHP.

Materials and Methods: A cross-sectional study of 100 college students (aged 18-26 years, CVA <53°) was conducted between December 2024 to February 2026 at the Department of Physiotherapy, Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation, Mullana, Ambala, Haryana, India. CVA was measured using photogrammetry with Kinovea software, AHWTT was recorded as the number of successful catches in 30 seconds. Reaction time was calculated by RDT. Normality was confirmed (Shapiro-Wilk); Pearson's correlation was used to assess correlation between the variables.

Results: Mean CVA was 38.16±5.26°. A moderate positive correlation was found between CVA and AHWTT performance (r=0.518, p<0.001). Small negative correlations existed between CVA and left-hand reaction time measures (r=-0.268, p=0.007; r=-0.265, p=0.008), while no significant correlation was observed with right-hand reaction time (r=-0.142, p=0.158).

Conclusion: Less severe FHP correlates with better eye-hand coordination and faster hand reaction time in asymptomatic students, supporting postural screening for early sensorimotor optimisation.

Keywords: Craniovertebral angle, Photogrammetry, Sensory

INTRODUCTION

The FHP has been recognised as one of the most common postural deviations in modern society, especially among young individuals and college-going students [1]. The widespread use of digital technology, poor ergonomic habits during extended study sessions and a sedentary lifestyle have been recognised as the main contributing factors in the rising number of FHP cases in the academic settings [2]. Although the link between FHP and cervical pain has been established, its correlation with neuromuscular performance parameters has yet to be fully explored [3].

The direct effect of postural alignment is linked to sensorimotor integration, proprioception and vestibular function, which are fundamental to accurate motor control and coordination [4]. The region of the neck contains a larger number of proprioceptors that provide continuous afferent feedback to the central nervous system, making it possible to perform accurate motor planning and execution [5]. When the head is positioned in an anterior position relative to the shoulders, as in FHP, the afferent feedback provided by the proprioceptors is altered, which may result in a reduction in the efficiency of coordinated movements [6].

Reaction time, or the time interval between the presentation of the stimulus and the initiation of the motor response, is an objective measure of the speed of sensorimotor processing [7]. Eye-hand coordination is a sensorimotor ability involving the integration of visual information and motor control to guide purposeful movements of the upper limb [8]. Both reaction time and eye-hand coordination are affected by postural stability and proprioceptive accuracy, indicating that postural abnormalities, such as FHP, may negatively impact these factors [9].

The CVA, calculated as the angle between a line passing horizontally through the spinous process of C7 and a line extending to the tragus of the ear, is a valid and reliable method of photogrammetry for the measurement of FHP [10]. It has been established in previous studies that a CVA of less than 53º is an indicator of FHP, while a value above this is considered to represent normal postural alignment [11,12]. The AHWTT is an objective test of bilateral eye-hand coordination [13].

Although the biomechanical implications of FHP and its impact on proprioceptive processing has been well established, there is a need to investigate the relationship between postural alignment and the performance of reaction time and eye-hand coordination tasks in asymptomatic college-age individuals. Such knowledge may have important implications for the early identification of at-risk individuals and the design of preventive strategies, as well as the optimisation of neuromuscular function.

The main aim of the present study was to explore the relationship between the FHP (CVA), reaction time and eye-hand coordination in asymptomatic college-going students. It was hypothesised that higher the severity of the FHP, the slower the speed of the reaction time and poorer eye-hand coordination.

MATERIALS AND METHODS

The present cross-sectional study was conducted from December 2024 to February 2026 at the Department of Physiotherapy, Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation, Mullana, Ambala, Haryana, India. It was approved by the Institutional Ethics committee (IEC/2024/3099). Written informed consent was provided by all participants and this study followed the Declaration of Helsinki (2013).

Sample size calculation: The minimum sample size for the correlation analysis was calculated using G*Power software (version 3.1.9) and it was found that sample of 84 participants is required to obtain a power of 0.80 with significance level of 0.05 and an expected medium effect size (r=0.30) [14]. To account for exclusion and have sufficient statistical power, 100 asymptomatic college students were selected for the study.

Inclusion criteria: Participants aged 18-26 years were enrolled. They were from current college students with CVA <53°, no cervical spine pathology or acute neck pain, no diagnosed neurological disorders affecting motor control and no history of head or cervical spine injury in the past 12 months [15].

Exclusion criteria: Participants with current or recent neck pain (Within three months); documented cervical pathology (herniated disk, stenosis, spondylosis); upper extremity injury that limits motor control; uncorrected visual impairments; use of medication that affect reaction time or motor coordination were excluded from the study [16].

Demographic and anthropometric assessment: Demographic variables were collected (age, gender). Height and weight measurements were done using standardised method (height measured to the nearest centimetre using a stadiometer and weight by electronic scale). Body Mass Index (BMI) was calculated.

Assessment of Forward Head Posture (FHP): The presence of FHP was measured by CVA calculated by photogrammetry, where the objects were photographed in a controlled lateral position. Anatomical points were identified for accuracy and pictures were taken from both sides with the subjects in a relaxed position [15]. The CVA was calculated using Kinovea software by measuring the angle formed between a line drawn from the tragus to the C7 spinous process and a horizontal line through C7. An angle of less than 53° indicates FHP, a threshold validated by high inter-rater reliability {Intraclass Correlation Coefficient (ICC=0.98)} [17].

Assessment of Eye-hand Coordination

Eye-hand coordination was measured by the AHWTT [18]. Participants stood 1.5 metres from the wall and alternately tossed a tennis ball with each hand, aiming for successful catches within 30 seconds. A successful catch was counted only if the ball bounced no more than once on the ground. Participants completed a 30-second familiarisation period followed by a 30-second rest before the test trial, during which the number of successful catches was recorded [19].

Assessment of reaction time: Reaction time was assessed using RDT, which is a valid technique that has a strong correlation (ICC=0.81, p<0.001) [20,21]. The Participants were seated comfortably with their arms resting on chair arm rest, with their hands ready to catch the ruler with thumb and index finger, the researchers held a 60 cm roller and dropped it suddenly encouraging the participant to catch the ruler as fast as possible. The distance of ruler it had fallen was measured and three trials were performed for each hand (RDT of the right and left hands) with a 30 second rest in between. The mean of the trial was calculated and then converted to reaction time in seconds using a designated online tool (https://www.topendsports.com/testing/tests/reaction-stick) [22].

STATISTICAL ANALYSIS

Statistical procedure performed using IBM Statistical Package for the Social Sciences (SPSS) statistics software (version 26.0). Descriptive statistics were employed for continuous data and normality test were conducted using the Shapiro-Wilk test, which confirmed normality (p>0.05). Therefore, a parametric test was employed and Pearson's correlation coefficient was calculated to determine the relationship between CVA, eye-hand coordination and reaction time with the significance level of α=0.05 (two-tailed) [23].

RESULTS

A total of 100 asymptomatic college-going students were considered for analysis. The participants were demographically homogeneous with a restricted age group (mean: 20.64±1.93) years, ranging from 18 to 26 years). The mean BMI was 21.58±3.77 kg/m^2, ranging from 12.70 to 32.00 kg/m^2, as per World Health Organisation (WHO) standards [Table/Fig-1] [24].

Variables	Mean±SD	Range (Min-Max)
Age (years)	20.64±1.93	18-26
Gender: Female, n (%)	50 (50%)	---
Gender: Male, n (%)	50 (50%)	---
Height (cm)	165.70±14.72	128.00-180.00
Weight (kg)	58.50±11.86	35.00-90.00
BMI (kg/m^2)	21.58±3.77	12.70-32.00
CVA (degrees)	38.16±5.26	24.00-49.00
AHWTT (catches/30 sec)	20.18±3.07	11.00-27.00
RDTRTAVG (cm)	24.05±4.85	13.00-34.00
RDTRTSEC (seconds)	0.226±0.062	0.16-0.79
RDTLTAVG (cm)	26.06±4.88	12.00-36.00
RDTLTSEC (seconds)	0.230±0.022	0.16-0.27

[Table/Fig-1]: Demographic and clinical characteristics of study participants (N=100).
BMI: Body mass index; CVA: Craniovertebral angle; AHWTT: Alternate hand wall toss test; RDTRTAVG: Ruler drop test right average distance; RDTLTAVG: Ruler drop test left average distance; RDTRTSEC: Ruler drop test right in seconds; RDTLTSEC: Ruler drop test left in seconds; denoting mean and SD (Standard Deviation).

The mean value of the CVA was 38.16±5.26 degrees, ranging from 24.0º-49.0º. Eye-hand coordination, as measured by AHWTT, had a mean of 20.18±3.07 catches in 30 seconds, with a range of 11-27 catches. Reaction time has measured by RDT, showed a mean right-hand reaction time of 0.226±0.062 seconds (range 0.168-0.790 seconds) and a mean left hand reaction time of 0.230±0.022 seconds (ranges 0.164-0.270 seconds).

Pearson's correlation analysis revealed a statistically significant moderate positive correlation between CVA and AHWTT scores (r=0.518, p<0.001), which suggested that individuals with better postural alignment (higher CVA values, less FHP) performed better in eye-hand coordination tasks [Table/Fig-2].

Small but statistically significant negative correlations were found CVA and left-hand reaction time variable (CVA vs RDTLTAVG: r=-0.268, p=0.007; CVA vs RDTLTSEC r=-0.265, p=0.008), indicating that individuals with better postural alignment (higher CVA) tend to have faster left-hand reaction time. Conversely, no statistically significant correlations were found between CVA and right-hand reaction times variables (CVA vs RDTRTAVG: r=-0.142, p=0.158; CVA vs RDTRTSEC: r=0.021, p=0.839).

Strong positive correlations were established between bilateral reaction time variables (RDTRTAVG vs RDTLTAVG: r=0.781, p<0.001; RDTRTAVG vs RDTLTSEC: r=0.773, p<0.001). No statistically significant correlations were identified between eye hand coordination (AHWTT) and reaction time variables (AHWTT vs RDTRTAVG: r=-0.084, p=0.409; AHWTT vs RDTLTAVG: r=-0.173, p=0.084).

DISCUSSION

In the present cross-sectional study, 100 asymptomatic college students were investigated for relationships between FHP measured by CVA, eye-hand coordination (AHWTT) and RDT. There was a moderate positive correlation between CVA and eye hand coordination (r=0.518, p<0.001), small negative correlations between CVA and left-hand reaction time (r ~ -0.27, p<0.01), indicating that individuals with better cervical posture tended

Variables	CVA	AHWTT	RDTRTAVG	RDTRTSEC	RDTLTAVG	RDTLTSEC
CVA	1	0.518 (p<0.001)	-0.142 (p=0.158)	0.021 (p=0.839)	-0.268 (p=0.007)	-0.265 (p=0.008)
AHWTT	0.518 (p<0.001)	1	-0.084 (p=0.409)	0.126 (p=0.212)	-0.173 (p=0.084)	-0.152 (p=0.131)
RDTRTAVG	-0.142 (p=0.158)	-0.084 (p=0.409)	1	0.250 (p=0.012)	0.781 (p<0.001)	0.773 (p<0.001)
RDTRTSEC	0.021 (p=0.839)	0.126 (p=0.212)	0.250 (p=0.012)	1	0.773 (p<0.001)	0.250 (p=0.012)
RDTLTAVG	-0.268 (p=0.007)	-0.173 (p=0.084)	0.781 (p<0.001)	0.773 (p<0 .001)	1	0.781 (p<0.001)
RDTLTSEC	-0.265 (p=0.008)	-0.152 (p=0.131)	0.773 (p<0.001)	0.250 (p=0.012)	0.781 (p<0.001)	1

[Table/Fig-2]: Pearson's correlation of all study variables (N=100).
BMI: Body mass index; CVA: Craniovertebral angle; AHWTT: Alternate hand wall toss test; RDTRTAVG: Ruler drop test right average distance; RDTLTAVG: Ruler drop test left average distance; RDTRTSEC: Ruler drop test right in seconds; RDTLTSEC: Ruler drop test left in seconds; p*<0.05 (two-tailed); **p<0.01 (two-tailed)

to demonstrate faster left-hand reaction time. However, no significant relationship was found between CVA and right-hand reaction time. Additionally, reaction time measures obtained from the right and left hands showed strong positive correlations ($r \approx 0.78$, $p<0.001$), indicating good consistency between bilateral reaction time measurements in the RDT).

The moderate positive correlation between CVA and AHWTT shows that less severe FHP is related better eye-hand coordination performance. Persons with higher CVA scores showed better coordination, which supports the role of postural alignment in the integration of proprioceptive feedback [11]. The high density of muscle spindles (36 spindles/gram in suboccipital muscles compared with 5-7/gram in limb muscles) and joint mechanoreceptors in the cervical area makes it easy to sense the position of the head and neck; however, the disruption caused by FHP may impair the integration of visual, vestibular and proprioceptive inputs, thus influencing coordinated eye-hand movements [25,26].

The results are in agreement with Goo BW et al., (2024), who found that cervical stabilisation with visual feedback significantly increased CVA and decreased joint position error in patients with FHP [27]. Postural positioning plays a crucial role in oculomotor and vestibular functions, as evidenced by studies that showed FHP can influence the mechanical efficiency of the extraocular muscles and vestibular reflexes [28]. A study conducted by Ha SY and Sung YH in 2020 revealed that a 40-minute temporary FHP with CVA <49° significantly reduce cervical proprioception by 1.7° ($p<0.05$) compared to the normal head posture of CVA >50° [29].

At variance with the initial hypothesis, CVA did not show any significant correlation with right-hand reaction time ($r=-0.142$, $p=0.158$; $r=0.021$, $p=0.839$), but small, significant negative correlations were found for left hand reaction time ($r=-0.268$, $p=0.007$; $r=-0.265$, $p=0.008$). The latter finding is novel and requires mechanistic explanation. Reaction time is a multifactorial construct, which is sensitive to attentional factors, central processing speed, motor planning efficiency and peripheral motor execution [30]. The influence of postural orientation on proprioceptive feedback may be modulated by other cognitive and neuromuscular variables, especially in asymptomatic subjects without obvious movement.

The increased sensitivity of the left hand may be related to hemispheric specialisation whereby in the right-handed population, the left hand is primarily controlled by the right hemisphere, which is more active in spatial attention and visuospatial processing [31]. The disrupted cervical proprioception due to FHP may thus have a greater impact on the right hemisphere mediated a spatial processing, leading to prolonged left hand reaction time with a relatively intact right-hand function.

Contrary to the present study results, Mohamed AA et al., (2022) Observed an increase in reaction times following feedback biofeedback corrective exercises for FHP in patient with Symptomatic cervical radiculopathy (pre: 253.8 ms; post: 218.2; $p<0.001$) [32]. Kubal S et al., (2023) observed a greater median response time in FHP subjects (CVA <49°) than normal posture controls (314 ms vs 298 ms; $p=0.001$) [33]. The lack of right-hand association in this asymptomatic population may indicate subclinical influences of FHP, possible compensation in young individuals, or the relative insensitivity of the RDT to posture related changes [4].

There were no significant correlations between AHWTT and reaction time (AHWTT vs RDTRTAVG: $r=-0.084$, $p=0.409$; AHWTT vs RDTLTAVG: $r=-0.173$, $p=0.084$). In a properly powered study (post-hoc power >0.95 for $r=0.30$), this indicates that AHWTT and simple reaction time, although both sensorimotor tasks, tap different neurocognitive constructs [13]. Eye-hand coordination (measured by AHWTT) requires continuous visuomotor integration, timing of predictions, bilateral motor sequencing and error correction over 30 seconds [4]. Simple reaction time (RDT) requires quick detection of the stimulus and onset of response with minimal motor planning [21].

This pattern is in line with hierarchical models of motor control, proposing that reaction time is a function of the efficiency of subcortical and primary motor pathways, whereas complex coordination tasks are mediated by higher order cortical networks [7]. Factor analytic studies in sports science have also shown that simple reaction and coordination tasks load on different factors, with common variance usually below 25% [20].

The high correlation between right and left hand reaction time ($r=0.781$, $p<0.001$; $r2=0.61$) reflects high bilateral consistency and suggests high internal reliability for the RDT [34]. Reaction time is a relatively stable neurophysiological characteristic in a person and mostly depends on how fast the brain processes information instead of how quickly the muscles act [34]. The results of high bilateral consistency ($r=0.78$) are in line with the previously reported high test-retest reliability of reaction time measurement ($r=0.79$. $p<0.001$) in young adults aged 19-25 years [4].

All subjects (100%) showed FHP, with a mean CVA of 38.16°±5.26°), which clearly reveals severe postural dysfunction among this population. The current study has revealed a higher prevalence rate of FHP than in previous Indian University study, with 80% in female students in Gandhinagar [35] and another study by Patel AS (2025) that revealed 62.39% in students wearing spectacles [36]. Furthermore, Singh S et al., (2020) found a 73% prevalence of FHP among students at Adesh University, with a mean CVA of 42.3°±6.8° among subjects with FHP [37].

The 100% prevalence rate in the present study is due to the inclusion criterion (CVA <53°) and not a true reflection of the population but emphasises the importance postural analysis and ergonomic adjustments in students with prolonged computer use and forward flexed study positions. These results support CVA based photogrammetric screening through possibly smartphone-based applications for identifying students prone to sensorimotor problems related to FHP. Specific corrective exercises and ergonomics knowledge about digital posture behaviour might help in improving posture as well as motor skills [16,37]. Moreover, specific training could also be taken into account for the better fine motor skills and postural analysis during athlete screening might help in optimising eye hand coordination [18].

The strengths of this study were that it used objective, standardised instruments for all variables. Photogrammetry is a valid method of posture quantification (intra-rater ICC=0.91, inter-rater ICC=0.75) [38] and the RDT has good concurrent validity with electronic timing (r=0.79) [21].

Limitation(s)

The limitations were that it was cross-sectional study, a convenience sample of asymptomatic physiotherapy students aged 18-26 years from single Institution were included and it used simple measures of visual reaction time coordination.

CONCLUSION(S)

The present study found significant associations between FHP and sensorimotor function in asymptomatic college aged subjects. FHP, as determined by the CVA, was positively associated with eye-hand coordination (r=0.518, p<0.001), but negative associated with left hand reaction time (r ~ -0.27, p<0.01). No significant association was found with right hand reaction time (r=-0.142, p=0.158), suggesting that these variables assess different dimensions of neurocognitive function. The 100% prevalence of FHP in the study population highlights the need for preventive strategies, suggesting that correction of posture could improve sensorimotor function beyond pain reduction models and in effect constitute effective strategies for postural correction.

Future studies should involve longitudinal and randomised controlled designs to better understand causality and intervention effectiveness, multi-center and more heterogeneous samples to improve generalisability and more sophisticated methods to better understand underlying neural mechanisms. Dose-response and ecological studies using wearable sensor technology may better capture real-time postural activity and sensorimotor deficits related to disease severity.

Acknowledgement

The authors would like to thank the participants and staff of Maharishi Markandeshwar Institute of Physiotherapy and Rehabilitation.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Feb 04, 2026
- Manual Googling: Mar 18, 2026
- iThenticate Software: Mar 21, 2026 (1%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Jan 31, 2026**
Date of Peer Review: **Feb 09, 2026**
Date of Acceptance: **Mar 25, 2026**
Date of Publishing: **Jun 01, 2026**