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Original Research Article

Exploring the relationship between craniovertebral angle, hand grip strength and handwriting performance in students

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ABSTRACT

Background: With the increasing reliance on mobile phones for communication, gaming, and internet use, musculoskeletal issues have become more prevalent, especially among students. Prolonged neck flexion, often associated with forward head posture (FHP), may compromise upper extremity function. Hand grip strength is considered a reliable indicator of upper limb integrity, while handwriting performance reflects fine motor coordination both potentially influenced by postural alignment. This study aimed to examine the relationship between craniovertebral angle (CVA), handwriting performance with hand grip strength among students.
Methods: An observational study was carried out over a 12-month period (June 2023–May 2024) at a tertiary care hospital in Southern Karnataka. A total of 77 students participated. CVA was measured using digital photogrammetry, hand grip strength with a handheld dynamometer, and handwriting performance through standardized writing tasks. Statistical analysis, including Pearson's correlation, was conducted using statistical package for the social sciences (SPSS) version 21.0 to evaluate the relationships among the variables.
Results: The analysis found a weak, negative correlation between grip strength and handwriting (r=-0.06, p=0.606), indicating a lack of statistical significance. There was no significant correlation between CVA and hand grip strength, nor between hand grip strength and handwriting performance.
Conclusion: The findings suggest that in this student population, there is no significant association between craniovertebral angle, hand grip strength, and handwriting performance. However, generalizability is limited due to the homogeneous age group and restricted sample diversity.

Keywords: Forward head posture, Craniovertebral angle, Hand grip strength, Handwriting, Musculoskeletal health

INTRODUCTION

In today's digital era, students often adopt prolonged static postures that can adversely influence musculoskeletal health.[1] One of the most commonly observed postural abnormalities in this population is forward head posture (FHP), which is quantified by the craniovertebral angle (CVA). A smaller CVA indicates a more pronounced forward head position, which has been associated with musculoskeletal discomfort and functional impairments in the cervical region.[2,3] Research suggests that such postural deviations are prevalent among students, influenced by factors like academic workload, sedentary lifestyle, and the field of study.[4]

FHP does not only affect spinal alignment but may also have distal consequences on upper limb function. Specifically, studies have shown correlations between altered cervical posture and changes in hand grip strength (HGS) an important marker of upper limb function and general health.[5,6] Grip strength is influenced by multiple factors, including neuromuscular coordination, body positioning, and shoulder stabilization.[7-9] Variations in neck, shoulder, and elbow positions can modulate the

maximal voluntary grip force a person can exert, possibly due to altered neural input or mechanical leverage.[10,11]

Furthermore, handwriting performance, a daily functional task for students, may also be indirectly affected by postural dynamics and upper limb strength. Previous investigations indicate that hand grip strength, upper limb endurance, and motor control contribute to handwriting speed and quality.[12,13] However, few studies have explored the integrative relationship between craniovertebral alignment, grip strength, and functional tasks like handwriting especially in a student population where academic demands and ergonomic stressors are significant.

Understanding the triadic interplay between CVA, grip strength, and handwriting performance may offer insights into optimizing student ergonomics and early interventions for postural corrections. Therefore, this study aims to investigate the associations between craniovertebral angle, hand grip strength, and handwriting performance in a healthy student population, contributing to a more holistic understanding of posture-related upper limb function.

METHODS

Study design and setting

This observational study was carried out at Laxmi Memorial College of Physiotherapy Mangalore, Karnataka, over twelve-month period from June 2023 to June 2024.

Study participants and sampling

The study recruited 85 subjects and included 77 subjects after the screening. Current study's inclusion criteria target individuals aged between 18 to 25 years, encompassing both males and females. Specifically, participants must be right-hand dominant and enrolled as full-time students. This comprehensive approach ensures that the study captures specific demographic and physiological characteristics relevant to the research objectives.

Data collection tool and technique

In this study, informed consent was obtained from all participants prior to data collection. Participants were selected based on inclusion criteria demographic details such as name, age, gender, body mass index and hand dominance were noted.

Each participant completed assessment of craniovertebral angle was done with photogrammetry, hand grip strength was measured with hand held dynamometer and handwriting was assessed using handwriting legibility scale. Each participant was subjected to three trials of measurements for craniovertebral angle, hand grip strength, and one trial for hand writing. After the data collection, the three components were correlated to determine their association in students.

The inclusion criteria for this study consisted of male and female students aged between 18 to 25 years, right-hand dominant, with no recent musculoskeletal, neurological, visual, or hearing impairments. The exclusion criteria included individuals with neck pain or a history of previous surgery involving the upper limb, hand, or neck.

Outcome measures

Craniovertebral angle

Participants were instructed to stand in a relaxed, natural posture. Reflective markers were placed on the spinous process of the 7th cervical vertebra and on the tragus of the ear. A lateral photograph was captured from the subject's dominant side using a mobile phone camera positioned 1.5 meters away at shoulder height. Before capturing each image, participants performed three to five repetitions of cervical flexion and extension, then returned to a neutral, static posture. Three such trials were conducted per participant. The images were analysed using Kinovea software (version 0.8.15), a free and open-access motion analysis tool. The CVA was measured for each trial image, and the average of the three readings was calculated to determine the final CVA value for each participant.[14]

Hand grip strength assessment

Participants were seated on an armless chair with the shoulder adducted and neutrally rotated, elbow flexed at 90°, forearm in a neutral position, and the wrist positioned between 0–30° of extension and 0–15° of ulnar deviation. These joint angles were verified using a universal goniometer. Participants were instructed to grasp the dynamometer handle and exert maximal force. Grip strength was recorded in kilograms (kg). Three trials were conducted for each hand, with a one-minute rest interval between trials to prevent fatigue. The average of the three readings was calculated and recorded as the final grip strength value for each hand.[15]

Handwriting legibility scale

Handwriting was evaluated using a validated handwriting legibility scale. Each participant was instructed to complete a free-writing task on an A4-sized sheet of lined paper, producing approximately 10 lines of text. A total of six minutes was allotted for the writing task, starting from the from the moment the participant began writing. The completed samples were assessed using the handwriting legibility scale, which comprises five components: legibility, effort, layout on the page, letter formation, alterations each component was rated on a 5-point scale, where higher scores indicate poorer performance. The total score was calculated by summing the scores for all five components, yielding a maximum possible score of 25, based on the total score.[16]

Statistical analysis

Data were analysed using statistical package for the social sciences (SPSS) 21.0 with a sample size of 77. The Normality of distribution was evaluated using the Kolmogorov-Smirnov test. The categorical variables were presented as frequency and percentage. Continuous variables presented as mean and standard deviation. To examine the relationship between craniovertebral angle, hand grip strength and handwriting in students the Spearman correlation coefficient test was applied. The significance level for the study was set at a 95% confidence interval ($p<0.05$).

RESULTS

The results of the study were assessed for normality using the Kolmogorov-Smirnov test. In this present study, a total of 77 participants had a mean age of 23.12±1.56 years, indicating a relatively homogeneous age distribution within the sample. The categorical variables were like age and gender were expressed in frequency and percentage (Table 1) and continuous variables like height, weight and basal mass index (BMI) were expressed as mean and standard deviation (Table 2).

Table 1: Distribution of age and gender.

Variables	Frequency	Percentage
Age (years)		
<22	9	11.7
≥22	68	88.3
Gender		
Female	64	83.1
Male	13	16.9
Total	77	100.0

Table 2: Representation of height, weight and BMI.

Characte-ristics	Min.	Max.	Mean	Std. dev.
Height	125.00	186.00	159.455	9.361
Weight	39.00	77.00	52.857	8.597
BMI	15.00	32.00	20.714	3.531

A total of 77 participants were included in the analysis. The CVA ranged from 42 to 65 degrees, with a mean value of 51.90 (SD=4.66), indicating moderate variability in head posture among the sample. Hand grip strength (HGS) values varied between 14 and 46 kg, with a mean of 23.47 (SD=5.43), reflecting a broad distribution of muscular strength. Handwriting scores ranged from 5 to 20, with an average score of 11.39 (SD=3.13), suggesting considerable differences in fine motor performance across participants. These descriptive statistics provide a foundational understanding of the sample's physical and functional characteristics (Table 3).

While examining the relationship between CVA and Hand writing with HGS, the results revealed no significant correlations. Specifically, there was a weak and negative correlation (Table 4). This suggests that the handgrip strength doesn't have a strong or significant impact on CVA and handwriting in the participants of this study.

Table 3: Mean and SD of CVA angle, HGS and hand writing score.

Charac-teristics	N	Min.	Max.	Mean	Std. dev.
CVA	77	42	65	51.896	4.661
HGS	77	14	46	23.468	5.428
Hand writing score	77	5	20	11.389	3.125

Table 4: Correlation between craniovertebral angle and hand writing with hand grip strength.

n=77	HGS	
	r value	**P value**
CVA	-0.214	0.034
Hand writing	-0.06	0.606

DISCUSSION

This study explored the relationship between CVA, HGS, and handwriting performance among students, in light of increasing concerns about postural deviations and their potential impact on fine motor function in youth. The results revealed no statistically significant correlation between CVA and HGS, and a weak negative correlation between HGS and handwriting scores ($r=-0.06$, $p=0.606$), indicating limited predictive value of these variables for one another in this population.

Our findings align with previous research indicating that CVA, a marker of forward head posture (FHP), does not significantly correlate with hand grip strength in asymptomatic young adults. Dsilva et al reported a negligible correlation coefficient ($r=0.033$), suggesting that postural deviations in the cervical spine may not directly influence distal muscle strength in healthy individuals.[17] Similarly, Mosaad et al found no significant association between CVA and grip strength across various postural groups, including those with rounded shoulder posture (RSP) and FHP.[14] This lack of correlation may be attributed to the localized nature of FHP, which primarily affects cervical musculature and proprioception, rather than the neuromuscular pathways governing hand function. Moreover, compensatory mechanisms in the upper limb may mitigate any biomechanical disadvantages posed by poor cervical alignment.

The lack of a significant correlation between hand strength and cervical spine posture deviates from previous hypotheses that postural alignment may affect the recruitment of upper limb muscles. Wong et al also

discovered that the head-neck position had little impact on the strength of the hand and elbow muscles, which supports the idea that HGS might stay stable even when cervical alignment changes.[18] Moreover, Jain and Sharma demonstrated that while altered neck posture is prevalent among professionals, it does not consistently impair hand function, suggesting the effect may be context-specific.[19]

Additionally, while CVA and HGS are biomechanically linked through cervical posture and upper limb function, our results align with previous research by Chauhan and Gujral, who found no significant correlation between cervical spine posture and hand grip strength in healthy collegiate individuals.[20] Their study emphasized that despite the anatomical proximity and functional interplay between the cervical spine and upper extremity musculature, postural deviations such as forward head posture may not directly influence grip strength in asymptomatic populations.

Interestingly, this contrasts with the findings of Butt et al who reported a moderate positive correlation between HGS and handwriting speed among DPT students (r=0.559 for strength and r=0.57 for endurance), suggesting that while strength may enhance writing fluency, it does not necessarily improve handwriting quality.[21] The weak negative correlation between HGS and handwriting scores in our study suggests that increased grip strength may not enhance handwriting performance. This aligns with findings from Kadaskar and Borkar, who emphasized the role of fine motor coordination and precise force regulation over raw strength in handwriting legibility.[22]

Nouman et al identified a significant positive correlation between CVA and HGS (r=0.459, p=0.01), suggesting that forward head posture often linked to prolonged smartphone use may diminish grip strength and elevate musculoskeletal risk.[23] The discrepancy between their findings and ours may stem from variations in participants' postural habits and smartphone usage patterns. These results underscore the need to account for ergonomic and behavioural influences when assessing musculoskeletal function in student populations.

Furthermore, while earlier studies by Rajabi et al reported notable differences in CVA based on gender and academic discipline, our study did not replicate these findings.[1] This divergence may be explained by our sample's demographic composition, which was predominantly female (83.1%), potentially limiting the scope for gender-based comparisons.

Handwriting is a complex neuromotor task requiring dexterity, endurance, and controlled pressure. Our findings suggest that fine motor control, coordination, and cognitive abilities likely play a more critical role in handwriting proficiency than grip strength alone. Furthermore, in practical contexts, this relationship may be mediated by elements like writing posture, writing practice frequency, and ergonomic tools.

Future research should examine fine motor skills and dynamic posture in greater depth, integrating factors such as ergonomics, psychological stress, and handwriting habits. Longitudinal studies are essential to track changes in postural alignment and muscle strength over time and their impact on motor performance. Additionally, intervention-based studies across varied populations can help uncover causal links and guide effective strategies to enhance posture and fine motor abilities.

The study had several limitations. Its cross-sectional design limits the ability to draw causal inferences between CVA, HGS, and handwriting performance. The participant pool, consisting exclusively of asymptomatic students, may reduce the applicability of results to clinical or more diverse populations with postural or neuromuscular conditions. Additionally, while the assessment tools employed were practical, they may not have adequately captured the complexity of fine motor coordination, dynamic cervical posture, and functional handwriting mechanics. External influences such as ergonomic setup, psychological stress, and habitual writing posture were not controlled, which may have introduced confounding variables affecting performance outcomes.

CONCLUSION

This study explored the relationship between craniovertebral angle, hand grip strength and handwriting performance in students, with the aim of understanding how handgrip strength is associated with posture and fine motor skills. The findings revealed that there is no significant correlation between CVA and HGS, and only a weak negative association between HGS and handwriting performance. These results suggest limited predictive value among these variables in students. Further research with broader ergonomic and neuromuscular considerations is recommended to better understand the factors influencing fine motor tasks.

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