Clinical Medicine and Health Research Journal (CMHRJ)
Volume 04, Issue 02, March - April, 2024
Page No. 816-822,

Research Article

Hand Function and Hand-Eye Coordination in Cervical Conditions – A Cross Sectional Study

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Received: 05 February, 2023 Accepted: 10 March, 2024 Published: 15 March 2024

Abstract:

Background of the study: Cervical Conditions are most common orthopaedic condition that may affect a large number of people. It compresses the nerve roots and may cause muscle weakness, numbness and loss of fine movements of the upper limbs. Hand Functions are movements of the hand and Hand eye coordination is the coordination of motor and visual inputs to produce a movement. This study helps to find out whether the hand function and hand eye coordination are affected in Cervical Conditions.
Aim: Aim of this study is to find whether the hand function and hand eye coordination are affected in Cervical Conditions.
Method: A total number of 212 subjects with cervical pain were screened for the study inclusion criteria and 132 subjects were selected for the study. The assessment of hand function, hand-eye coordination skills and shoulder disability were carried out for all the Subjects. NDI scale was used to evaluate the subject's severity of pain and the associated disability among the samples. Hand function we evaluated using Purdue pegboard. Ball Tossing Task and Wall Ball Bounce Task were done to assess the Hand eye coordination.
Results: On assessing the correlation between NDI and PURDUE, the results obtained on analysis is -0.108, which shows a negative relationship between the variables. The non-parametric correlation analysis using the spearman's rho between the Neck disability index (NDI) with the PURDUE is -0.053, which shows a negative relationship between the variables. On assessing the correlation between NDI and Hand-Eye Task-1, the results obtained on analysis is -0.0081, which shows a negative relationship between the variables and the non-parametric correlation analysis is -0.162, which shows a negative relationship between the variables. On assessing the correlation between NDI and Hand-Eye Task-2, the results obtained on analysis is -0.023, which shows a negative relationship between the variables and the non-parametric correlation analysis is -0.092, which shows a negative relationship between the variables.
Discussion: The purpose of the study is to find whether the hand function and hand eye coordination are affected in Cervical Conditions.
Conclusion: This study concludes that the hand function and hand eye coordination are not affected in Cervical Conditions.

Key words: Balloon Tossing Task, Cervical Conditions, Hand eye coordination, Hand Function, Neck Disability Index, Purdue peg board, Wall ball Bounce test.

1. Introduction

Growing evidence supports altered proprioception will affect the acuity in upper limb movements in patients with neck pain. Previous have demonstrated that patients with whiplash-associated disorders had an altered joint position sensation associated of the head and neck and presented with altered repositioning acuity of the shoulder [1]. Altered acuity of goal-directed upper limb movement, kinaesthesia and proprioception was proved in patients with severe neck pain. [2].

Furthermore, the reduced simple reaction time of the foot was identified to be accompanied by a decreased cervical range of motion [3]. Steinmetz and Jull in 2013, identified that there is no impairment of upper limb motor performance (that is reaction time, movement velocity, precision, and coordination) in musicians who are with neck ache correlated to asymptomatic musicians. Various factors both extrinsic (task-related) and intrinsic (subject-related) can indicate the sensorimotor processing and integration [4], although the reason for the discrepancy among study measures was found to be unclear.

However, Reaction and response times play a major role in day-to-day activities. Several activities such as driving and writing are based on increased precision response and movement. Finally, even small improvements in movement variability can lead to higher performance error [5]. Until now, many attempts have been performed to analyse motor performance particularly reaction time, movement time, and hand-eye coordination in individuals with neck disorder. Hence, this research aimed to analyse both hand and foot reaction and response times and hand-eye coordination in persons with prolonged non-specific neck aches. The correlations between reaction, response times and hand-eye coordination and among these findings and the

signs and symptoms of neck pain were also analysed. It was conceptualised that persons with neck pain may present with altered reaction and movement times and also altered hand-eye coordination compared to age-related normal. Moreover, there would be some correlations among reaction and response times and hand-eye coordination, and among the signs and symptoms of neck pain and each finding. There are many studies in the past that have correlated severe neck conditions with hand function and hand eye coordination. But in the current phase of the study, a cross sectional analysis was performed to find the influence of painful cervical conditions without the involvement of the myotome in hand function and hand eye coordination.

2.Methods and Methods

A total number of 212 subjects with cervical pain were screened for the study inclusion criteria and 132 subjects were selected for the study. Both male and female between 30 to 60 years were selected for the study. The selected subjects had a history of cervical pain which was expressed in chief complaint as pain around the neck, or the trapezius or neck pain with pain along the medial scapula or proximal arm. The subjects have a history of ailment for a minimum period of one-month duration and a maximum of 12 months. Subjects who had a radiating pain with severity more than 8 on Visual analogue scale or subjects who had pain in dermatome region rather than neck were excluded from the study. Subjects who had weakness of the upper limb on manual muscle testing either in the peripheral nerve distribution or the myotome distribution were excluded. Subjects who had a history of fracture, internal fixation anywhere in the affected upper limb or cervical spine, any conditions of the upper limb or the cervical spine like vertigo that might influence the HF were excluded from the study. Subjects with altered sensation, severe systemic problem and general health depleted subjects were not considered for the study.

The assessment of hand function, hand-eye coordination skills and shoulder disability were carried out for all the Subjects. NDI scale was used to evaluate the subject's severity of pain and the associated disability among the samples [6]. Hand function / dexterity were evaluated using Purdue pegboard. Two blinded assessors were used in the analysis, one assessor was responsible for measuring the time using a standard stopwatch, and the other was used to monitor the task for both HF and HEC tests. There were three tasks performed by every subject three times with a gap of 60 seconds between each attempt [7]. In the first subtask, the subject has to place maximum number of pegs in the target holes of the pegboard in a span of 30 seconds. The Subjects were asked to perform this task consecutively with both hands. For the first attempt hand was selected randomly. Task number two required the subjects to place as many pegs as possible using both hands, by placing pegs simultaneously. The third task required the subject to place the peg, then the washer and followed by the collar in a sequence prescribed by the guidelines [8].

A battery of hand-eye coordination tests was administered to the patient as follows.

Drill 1 – Balloon tossing task -The subject had to bounce a balloon vertically up, back and forth with the affected hand, as long as possible, followed by the normal hand. The task had to be continued as long as possible and the subjects were not allowed to catch the balloon. The task was repeated three times on each hand. The best score for each hand was added and then used for statistical analysis.

Drill 2 - Wall Ball Bounce task - The subjects stood 2M away from a wall and tossed a tennis ball onto the wall in a self-passed manner. The subject had to catch the ball on return with a single hand at first attempt without fumbling. The number of times the subject successfully performed the task in 60 seconds was measured. The test was performed with both hands. The task was performed only once and the score thus obtained for each hand was added and was used for statistical analysis.

3.Results

A total number of 212 subjects were screened for the study out of which 132 subjects fulfilled the selection criteria. There were no subjects opting out of the study due to the anxiety. 132 subjects participated in the study and completed all the tests. The demographic details of the subjects are provided in **Table 1**. The scores of NDI were correlated with the scores of Purdue pegboard scores and the hand-eye coordination scores using a Spearman's correlation as the data were ordinal. SPSS version 26 was used for the data analysis were provided in **Table 2, 3, 4, 5, 6 & 7**.

Table 1. Demographic data of the participants

Criteria	Numbers
Age	
30-40 years	68
40-50 years	44
50-60 years	20
Sex	
Male	74
Female	58
Involved side	
Unilateral symptoms	83
Bilateral symptoms	49
Duration of ailment	
Less than 1 months	66
1 to 4 months	29
4 to 8 months	24
8 months to 12 months	13
Conditions	
Postural syndrome	40
Dysfunction syndrome	08
Derangement syndrome	84

TABLE 2 Correlations Between the NDI Vs Purdue

Correlations		
	PURDUE	NDI

PURDUE	Pearson Correlation	1	-0.108
	Sig. (2-tailed)		0.217
	N	132	132
NDI	Pearson Correlation	-0.108	1
	Sig. (2-tailed)	0.217	
	N	132	132

Table 2. shows the correlation analysis between the Neck disability index (NDI) with the PURDUE. 132 participants were analysed for the relationship between NDI and PURDUE. The results obtained on analysis is -0.108, which shows a negative relationship between the variables. So, this finding of the research indicates that there is no correlation identified between the NDI and PURDUE.

Table 3. Nonparametric Correlations

Correlations				
			PURDUE	NDI
Spearman's rho	PURDUE	Correlation Coefficient	1.000	-0.053
		Sig. (2-tailed)	.	0.548
		N	132	132
	NDI	Correlation Coefficient	-0.053	1.000
		Sig. (2-tailed)	0.548	.
		N	132	132

Table 3 shows the non-parametric correlation analysis using the spearman's rho between the Neck disability index (NDI) with the PURDUE. 132 participants were analysed for the relationship between NDI and PURDUE. The results obtained on analysis is -0.053, which shows a negative relationship between the variables. So, this finding of the research indicates that there is no relationship identified between the NDI and PURDUE on non-parametric correlations.

Table 4. Correlations Between the NDI Vs Hand- Eye Task-1

Correlations			
		NDI	HAND EYE TASK-1
NDI	Pearson Correlation	1	-0.0081
	Sig. (2-tailed)		0.354
	N	132	132
HAND EYE TASK1	Pearson Correlation	-0.081	1
	Sig. (2-tailed)	0.354	
	N	132	132

Table 4 shows the correlation analysis between the Neck disability index (NDI) with the Hand-Eye Task-1. 132 participants were analysed for the relationship between NDI and Hand-Eye Task-1. The results obtained on analysis is -0.008, which shows a negative relationship between the variables. So, this finding of the research indicates that there is no correlation identified between the NDI and Hand-Eye Task-1.

Table 5. Nonparametric Correlations Between the NDI Vs Hand- Eye Task-1

Correlations				
			NDI	HAND EYE TASK1
Spearman's rho	NDI	Correlation Coefficient	1.000	-0.162
		Sig. (2-tailed)	.	0.064
		N	132	132
	HAND EYE TASK1	Correlation Coefficient	-0.162	1.000
		Sig. (2-tailed)	0.064	.
		N	132	132

Table 5 shows the non-parametric correlation analysis using the spearman's rho between the Neck disability index (NDI) with the Hand-Eye Task-1. 132 participants were analysed for the relationship between NDI and Hand-Eye Task-1. The results obtained on analysis is -0.162, which shows a negative relationship between the variables. So, this finding of the research indicates that there is no relationship identified between the NDI and Hand-Eye Task-1 on non-parametric correlations.

Table 6. Correlations Between the NDI Vs Hand- Eye Task-2

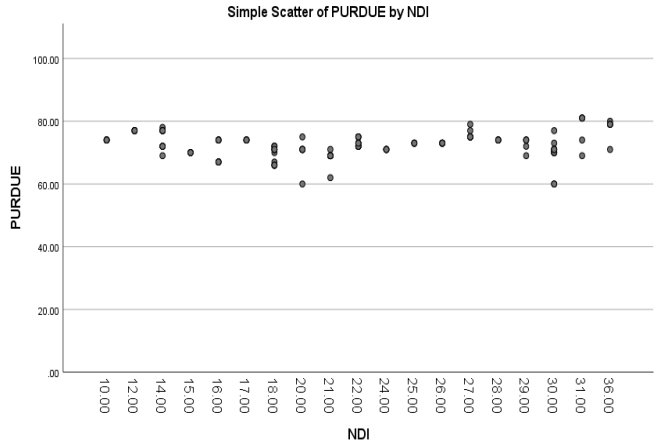
Correlations			
		NDI	HAND EYE TASK-2
NDI	Pearson Correlation	1	-0.023
	Sig. (2-tailed)		0.790
	N	132	132
HAND EYE TASK2	Pearson Correlation Sig. (2-tailed)	-0.023 0.790	1
	N	132	132

Table 6 shows the correlation analysis between the Neck disability index (NDI) with the Hand-Eye Task-2. 132 participants were analysed for the relationship between NDI and Hand-Eye Task-2. The results obtained on analysis is -0.023, which shows a negative relationship between the variables. So, this finding of the research indicates that there is no correlation identified between the NDI and Hand-Eye Task-2.

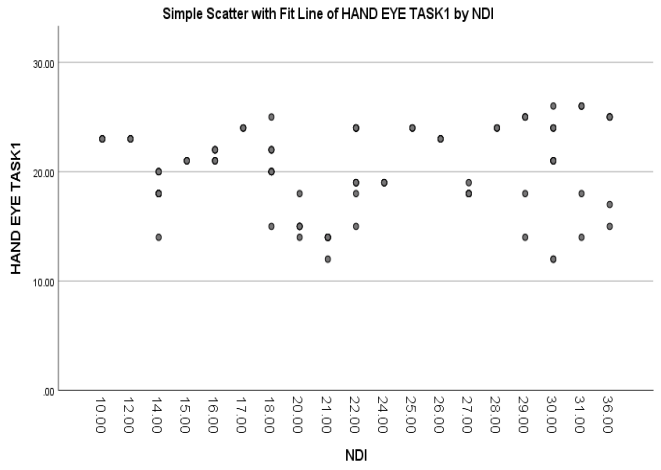
Table 7. Nonparametric Correlations Between the NDI Vs Hand- Eye Task-2

Correlations				
			NDI	HAND EYE TASK-2
Spearman's rho	NDI	Correlation Coefficient	1.000	-0.092
		Sig. (2-tailed)	.	0.292
		N	132	132
	HAND EYE TASK2	Correlation Coefficient	-0.092	1.000
		Sig. (2-tailed)	0.292	.
		N	132	132

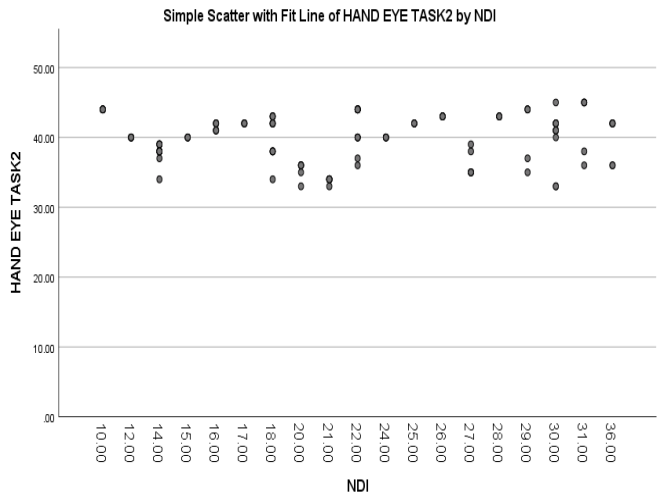
Table 7 shows the non-parametric correlation analysis using the spearman's rho between the Neck disability index (NDI) with the Hand-Eye Task-2. 132 participants were analysed for the relationship between NDI and Hand-Eye Task-2. The results obtained on analysis is -0.092, which shows a negative relationship between the variables. So, this finding of the research indicates that there is no relationship identified between the NDI and Hand-Eye Task-2 on non-parametric correlations.



Graph I



Graph II



Graph III

4.Discussion

Neck pain is becoming one of the common musculoskeletal problems which affect a substantial percentage of individuals at some point in life. Many neck pain individuals have reported associated upper limb symptoms and upper limb activity restrictions [9]. The common cause of neck pain is prolonged work postures, awkward posture, and maintenance of poor posture for a longer duration, forcing the muscle to overload over the neck and shoulder regions [10]. There has been identified that neck pain has associated with upper limb dysfunctions [11].

Neck pain has the symptoms of pain and tenderness over the muscles. In addition, it also involves deficits in sensorimotor functions. Many mechanisms may contribute to the pain from overloading over the cervical segments; force is transmitted to the cervical spine through the axio scapular muscles, like levator scapulae and upper trapezius [12,13]. The forces in the cervical region source for the pain in cervical structures, which cause pain that inhibits the performance of upper limb activity. Sensorimotor deficits extend beyond the cervical region and include the upper limb tasks and the hand-eye coordination with postural sway [14]. Prolonged loading could increase the loss of scapular control and impairment in muscle activation, resulting in distress around the neck [15]. Alteration in the head position causes biomechanical changes during the flexion of the spine. There is an increase in tension on the nerve roots, affecting muscle strength [16]. There is an alteration in the mechanical properties of the muscles, which include the stiffness, elasticity, and changes in the cervical regions [17].

Clinically, it is noted that the non-specific neck pain has not reported problems with the upper limb functions. However, it is not known that cervical pathologies or impingement of the nerves in the cervical region may cause upper limb deficits. [18]. The impingement of the nerve might lead to weakness over the muscles supplied. There may be pain observed as deep and sharpshooting, sensory deficits over the nerve root, reduction or absence of deep tendon reflexes, and motor deficits [19]. Nerve impingement could result in sensorimotor deficits, which work in tandem with motor functions. Defective functioning of the sensorimotor could cause abnormal proprioceptive information to the dermatomal areas, which may cause a delay in the reaction stimuli and alteration in speed and accuracy [20].

The cervical condition may affect the hand functions because of the compromises in the myoneural conductions with reducing the tissue blood flow and oxygenation [21]. Mechanical loading to the cartilages and the ligaments around the joint of the cervical vertebra cause increase in loads on the upper limbs, which causes pain in the upper limbs and difficulties in performing the upper limb activities, which intern result in disabilities [22]. A study by Fayez 2014, showed that a marked reduction of the grip strength noted in cervical pain individuals and identified that it is due to a deficit in the quality of the sensory information's which generates motor outputs or due to sensory hyperexcitability [23]. Some studies identified changes in the nervous system on the activation of the muscles

around the hand [24]. Hypothetically, neck pain could result in a deficit in sensory information quality that generates motor output [23].

Sensorimotor impairments to the neck are established but whether it affects the upper limb functions is unclear. Various hypothetical explanations have identified that there will be hand deficits following cervical dysfunctions [14]. However, which type of cervical lesions possess the hand deficits or the hand-eye coordination deficits are still unknown [25]. Recent researchers have identified head and trunk coordination in neck pain individuals; still, there is no clinically determined level of impairment [26]. Neck muscles have muscle spindles, which are high density and are essential for joint position and movement senses [27]. A change in sensory input from the cervical area may be linked to faulty sensorimotor integration [28].

There is a lot of evidence that changes in sensorimotor function are related to neck discomfort [29]. Such alteration may influence the visual pathway and cause visual disturbances, reduction in the cervical proprioceptive acuity, altered eye and head movement control, and impairment in balance. Growing evidence also suggests an impaired proprioceptive sense in arm movements associated with neck pain [30].

Hand function or strength is due to the muscles' combined contractions, affecting the upper limb's position. The strength may also be due to the situation on the upper limbs [31]. One of the possible explanations of the hand function deficits is repetitive and monotonous movements, which impact the muscular structures around the neck and may reduce the strength [32]. The statement was contradicted by various authors and showed that there is neither difference between manual and non-manual workers' handgrip [33]. There is no difference between non-dominant and dominant hands [34].

Repetitive tasks cause physiological adaptations in the muscles, and the long-term activity results in force-related transformations within the muscular systems [35]. They were comparing the handgrip with the different wrist positions and the neck pain with and without revealed no change [36]. The study that compared neck pain with hand strength and the wrist position showed that neck pain and hand function are not much related [37].

This study also identifies no slowness in hand-eye coordination and reactions in mild cervical conditions. The study Sittikraipong et al., 2020, states that there are slower hand and foot reactions and delays in the response time in the various cervical conditions. They also noted impaired hand-eye coordination, which suggests it is a sensorimotor deficit [30]. However, this study has more female participants with mild pain and mild disability. So, this couldn't be considered supportive literature, and these research findings show no relationship.

Sensory receptors around the neck are affected by various causes around the neck and neck-related pathologies. Pain alters the muscle spindle activity, and this results in impairment of neck function. There is an alteration of the cervical afferent input by changing proprioception, joint mechanics, and sensitivity of the muscle spindles [28]. Studies also found that the degenerative changes in the cervical spine play a significant role in the motor, sensory, and autonomic neurons in a hyperexcitable state. It also increases blood vessel tone and renders connective tissues more susceptible to injury [21].

The study by Wollesen et al., 2020, finds that neck disorders influence neck pain over the wrist, and hand pain is not more significant. In contrast, they also suggested that women are more affected by wrist pain, which the neck postures may influence. A study done by Gadotti et al., 2020, explains that hand-eye coordination deficits were observed following whiplash injuries compared with healthy individuals; however, the amount of the impact and the types of damages are not discussed well [38].

A similar study found no impairment of the upper limb motor performances like the accuracy, hand-eye coordination, tapping speed, and reaction times in neck pain compared with the asymptomatic musicians [39]. Several task-related or subject-associated activities may influence sensorimotor processing and integrations [4], but the discrepancies between study findings are unclear.

This study results have identified that mild cervical conditions or mechanical neck pain contribute little to hand-eye coordination. This research also determined that the cervical conditions would influence hand functions or hand-eye coordination when nerve impingement is seen. Furthermore, the hand function can be elaborately tested to identify the exact mechanism behind it.

5.Conclusion:

This study analysis shows a negative relationship between the neck disability and the Purdue, hand-eye task-1, and hand-eye task-2 in individuals with cervical conditions. Even though some studies have shown some relationship exists with neck pain and handgrip or hand function, or hand-eye coordination, all these studies were done on the various chronic cervical pathologies. No studies have identified the relationship between mechanical or postural neck pain the hand functions. This study also doesn't support the relationship between neck pain and hand-eye coordination. So, this research work is not carried to the next phase of the research. Further research is needed to explore the possibilities of neck pain and its severity on influencing the hand-eye coordination tasks.

6.Ethical Approval and consent to participate

This cross-sectional study was conducted at the outpatient department of XXX College of Physiotherapy, Chennai. Ethical clearance was obtained for the study from the institutional ethical committee, XXX College of Paramedical Sciences, College of Physiotherapy (IEC no. 001/04/2022/IEC/XXXCOPT) on 11th April 2022. All the subjects who participated in the study were clearly explained about the study before participation and were requested to sign an informed consent.

7.List of Abbreviations

NDI – Neck Disability Index
HF – Hand Functions

HEC – Hand Eye Coordination
SPSS – Software Package for Statistical Analysis in Social Sciences

8.Conflict of Interest

None declared by the authors

9.Funding Statement

No Grant or Financial Support obtained.

10.Authors' Contribution

SKB contributed to the study concept, design, analysis of the data, prepared the first draft of the paper and revised the manuscript.
AR has helped in data acquisition.
Both authors read and approved the final manuscripts.

11.Acknowledgment

The authors express their gratitude to all participants and the XXX College of Physiotherapy administration for allowing to research in their campus

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