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To Determine The Effect Of Cervical Muscle Fatigue And Its Correlation With Visual Acuity

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Abstract

Background: Balance of Posture and visual accuracy rely on the input from the visual-vestibular and somatosensory units that are processed through CNS. Faulty information will result in a discrepancy of information that will lead to an imbalance of postural and visual stability. **Objective:** To determine the correlation between cervical muscle fatigue and visual acuity. **Methods:** 36 participants with ages ranging from 21-30 years were selected and divided into experimental and the control group respectively. Both groups ' fatigue levels and dynamic visual Acuity (DVA) were assessed before intervention. The dynamic visual acuity was to be assessed with and without induction of fatigue. Group A (the experimental group) had neck fatigue induction using the neck endurance test (NET) for both flexors and extensors, while Group B performed sham exercises that produced no fatigue. The Fatigue level and DVA were assessed immediately after the intervention. **Results:** there was a notable difference in the experimental and control group when the visual acuity was measured. The participants in the experimental group showed a remarkable decrease in visual acuity as compared to the other group. The result also showed a strong correlation between muscle fatigue and dynamic visual acuity (r=.642). **Conclusion:** A positive correlation was noted between cervical muscle fatigue and visual acuity.

Keywords: dynamic visual acuity, cervical muscle fatigue.

INTRODUCTION

Balance of Posture and visual accuracy mainly rely on the input form the visual vestibular and somatosensory units that are adeptly and precisely processed through the CNS (Page, 2011). This afferent input, during its processing, encounters multiple modes of sensory in-co-operation involving different areas of brain and brainstem to yield efferent output accurate enough to preserve symmetry of posture and oculomotor control (Kristjansson & Treleaven, 2009). Faulty information processed from defective sensory organs will result in discrepancy of information that will lead to an imbalance of postural and visual stability (Page, 2011). There are several factors involved in such information conflict that includes vestibular and neurological deficits, drug induced side effects and injury to cervical spine such as Whiplash injury (Kristjansson & Treleaven, 2009; Page, 2011).

Cervical muscles play a key role in maintenance of postural stability through proprioceptive input. (Reddy, Maiya, & Rao, 2012). Muscle fatigue can alter the sensory receptors firing rate (Gosselin, Rassoulian, & Brown, 2004; Page, 2011; Wrisley, Sparto, Whitney, & Furman, 2000). Dorsal root ganglion of C2 is the major ganglion responsible for transmission of information from upper portion of cervical spine. (Kristjansson & Treleaven, 2009; Page, 2011). Many reflexes such as cervical colic reflex (CCR) cervical ocular reflex (COR) as well oculomotor control postural integrity and head alignment etc. are controlled by cervical spinal reflexes (Reddy et al., 2012).

Problems like visual imbalance instability of posture and dizziness will arise if there is any perturbation in the analogy of these interrelated systems that will result in misinterpretation of information received through sensory integration of the system. (Kristjansson & Treleaven, 2009) Importance of muscle fatigue in postural imbalance is also highlighted by evidence as it alters proprioception by remodeling the firing of sensory receptors present in neck muscles.(Reddy et al., 2012)

Arduous work out can lead to body undulation because of the modified proprioception. As suggested by evidence, there is an imbalance of stabilizers of the neck muscle that leads to postural instability, which ultimately leads to increased pain, incapability in maintaining proper alignment and decreased strength of the muscles owing to compromise in performance.(Reddy et al., 2012)

A study examined the proprioception differences between standing and sitting postures. This study involved 60 students (m/f, 12/48) from d university in Gyeongsangbuk-do, South Korea. With the subject's eyes closed, a JPET was conducted to evaluate the proprioception of the neck. When standing and sitting, the neck's flexion, extension, and lateral flexion were all measured independently. Using a paired t-test, the difference in repositioning errors between sitting and standing postures was examined. Between sitting and standing postures, there was a substantial difference in repositioning errors for neck extension. In neck flexion and lateral flexion, there was no discernible difference in repositioning errors between sitting and standing posture. (KIM, SHIN, & KIM, 2021)

Another investigation on proprioception and postural stability via cervical flexor muscle tension. 45 participants were selected and a fatigue induction protocol was applied. The subjects were assessed before applying during and after applying the protocol. The Joint positional error test (JPE) was used to test proprioception and the multi-directional reach test and biodex balance system was the tool used for testing postural stability. The result showed that immediate post-induction of fatigue, there was a significant decrease in cervical proprioception (cervical joint position error test) and postural stability (biodex balance system & multidirectional reach test) compared to both before induction of fatigue and after recovery from fatigue (p0.001). (Abdelkader, Mahmoud, Fayaz, & Saad El-Din Mahmoud, 2020)

Yeo, Sang-Seok, et al, analyzed how adults with a forward-head posture with dorsal neck muscle exhaustion affected their cervical range of motion (CROM) and proprioception (FHP). This study included thirty pain-free participants. To calculate the FHP, the forward head angle of each subject was assessed by taking a picture of their upper bodies in the sagittal plane. Before and after producing muscular exhaustion in the dorsal neck, all subjects had their CROM and Head repositioning accuracy (HRA) for joint proprioception assessed. Neck flexion, extension, right-left lateral flexion, and right-left rotation were used to measure the CROM and HRA. After dorsal neck muscle exhaustion, total CROMs significantly decreased in both groups (p 0.05). After dorsal neck muscle exhaustion, total HRAs significantly increased in the FHP group (p 0.05). (Yeo & Kwon, 2020)

Very limited evidence is available regarding the relationship between proprioception, cervical spine and VOR and it provides little information about its influence on VOR of humans. The purpose of this study is to investigate whether fatigue of cervical muscle has any impact on Dynamic Visual Acuity (DVA).

Objectives of the study: to determine the correlation between cervical muscle fatigue and visual acuity. **Hypothesis:** $H_{A:}$ Cervical muscle fatigue will have an impact on the dynamic visual acuity $H_{0:}$ Cervical muscle fatigue will not affect dynamic visual acuity

METHODOLOGY

Quasi Experimental study was performed at Jinnah Hospital. Approval was taken from head of physical therapy department. Non-probability purposive sampling was used as a sampling technique. The sample was 36; estimated using the method for inferential designs, with the power of the study set to 90%, the threshold of significance set to 95%, and the confidence interval set to 95%. Healthy young adult’s b/w age 21 to 30 with no history of cervical damage, such as whiplash were selected.

Individuals were screened for any disruption in the Visual and vestibular somatosensory systems Cervical stability (alar ligament test, Sharp-Purser test, and lateral shear test), cervical vascular screening (modified vertebral artery test), vestibular system screening (HallpikeDix test, roll test, head thrust test, head-shaking-induced by nystagmus test, static and dynamic visual acuity) were all included in the screening. Participants having any history of cervical pain and trauma. BPPV (benign paroxysmal positional vertigo) vestibular hypofunction, balance, and vertigo due to ear dysfunction, migraine-associated vertigo) and visual disorders such as low vision, myopia, hyperopia, were excluded.

Each participant gave his or her informed approval**.** The subjects were divided into 2 groups, Group A and B. Neck muscle fatigue was measured by MVA (Modified Visual Analogue Scale) (Pinsault & Vuillerme, 2010), which was a numeric scale rating from 1 to 10; 1 corresponding to no fatigue at all, whereas a score of ten denotes the highest level of fatigue perceived. Fatigue level was measured before and after the intervention. The isometric cervical muscle endurance test (NET) was used to induce cervical muscle fatigue (Abdelkader et al., 2020)

The participants in the test were asked to hold the head and neck in a position up to the point where fatigue or debility occurred. The position to induce flexor muscle fatigue in participants in Experimental group A was crook lying. The hands were placed on the abdomen. The subjects were instructed to lift their heads 2.5 centimeters above their resting position. The hand of the therapist was placed under the head. For Extensor muscle fatigue, the subject was instructed to lie prone with the head on the edge of the bed. A stool was used to support the head. The subject was instructed to maintain both positions until he felt pain or was unable to continue. (Abdelkader et al., 2020) A total of three neck lifts were performed by each patient in flexion and extension and the fatigue level was immediately measured after the intervention.

Group B participants were required to sit in a chair with their backs to the wall. They wore a headband or a cap with a laser affixed on the top. On the wall, four targets with the same shape and width were placed. (Center, down, left, and right) at the level of the subject's eye. Participants began first with their heads in a neutral position pointing the laser inside the central target. Then the participants were asked to point to the second target by rotating the head and then getting back to the starting. The same instructions were followed for 5 minutes for each target by participants: center down, center-right, and center-left (with 1 or 2 mins break in between). There was no fatigue in performing this sham exercise. Participants kept their eyes open during the exercise. (Al Saif & Al Senany, 2015)

Individuals' static and dynamic acuity were assessed before and after therapy using a dynamic visual acuity test. The values recorded were converted into log MAR because it is the unit for visual clarity. Changes of one line (0.1 LogMAR) or less (0.1) were regarded normal, but changes of two or more lines (> 0.2) were judged abnormal, according to Herdman et al. (Al Saif & Al Senany, 2015)

SPSS for Windows version 20.0 was used to analyze the data. For the continuous variables age, DVA, and gender, frequencies and relative frequencies were computed, and means and standard deviations (SD) were calculated. The normality of the data was confirmed using the Shapiro-Wilk test. The difference between the mVAS and DVA values at baseline and the end of the trial was calculated, The DVA and Fatigue correlation was investigated. The significance level was set at 0.05.

DATA ANALYSIS AND RESULTS

Table 1 showed the gender distribution of the two groups. Group A had 10 males (0.28%) and 8 females (0.22%), whereas goup B had 11 males (0.30%) and 7 females (0.19%).

Table 1 Gender Description of Groups

Groups	Gender	Frequency	Percent
A Experimental Group	Male	10	0.28%
	Female	8	0.22%
	Total	18	50%
B Control Group	Male	11	0.30%
	Female	7	0.19%
	Total	18	50%

Table 2 Variables of groups

Variables	Group A N=18				Group B N=18			
	Mean	St.Dev	Min	Max	Mean	St.Dev	Min	Max
Age	23.16	1.24	21.0	25.0	22.7	1.00	21.0	24.0
Height	9.02	14.7	5.3	68.0	5.6	.25	5.3.0	6.0
Weight	57.83	10.4	38.0	75.0	61.5	7.8	49.0	77.0

Table 2 demonstrates the baselines of Groups A and B before intervention. Group A had a mean age of 22.7 with an SD of 1.24 while Group B has a mean age of 22.7 with an SD of 1.00. The height of group A had a mean of 9.02 with 14.7 SD whereas Group B had a mean height of 5.6 and SD of 0.25. The weight of

Group A had a mean of 57.83 and SD of 10.4 and Group B had 61.5 and SD of 7.8.

Table 3 Fatigue level between group A and B before and after intervention (Mann-Whitney U test)

Group		**N**	**Mean**	**SD**	**Mann-Whitney U**	**P value**
Fatigue Level of participants before exercise	Group A	18	1.27	.65	147.000	.589
	Group B	18	1.50	.50		
	Total	36				
Fatigue Level of participants after exercise	Group A	18	4.77	2.50	0.00	0.00
	Group B	18	1.50	.50		
	Total	36				

The fatigue level was measured before and after exercise. The means of groups A and B before exercise were 1.27 and 1.50 and after exercise were found to be 4.77 and 1.50 respectively. The result showed that there were insignificant differences between the two groups before exercise (p-value .589), but there was a highly significant difference between the two groups post-exercise. (p-value 0.00)

Table 4 Comparison of visual acuity of both groups pre and post intervention (Mann Whitney U test)

Groups		**N**	**Mean**	**SD**	**Mann Whitney U**	**P value**
Dynamic visual acuity of participants before exercise	Group A	18	.20	.042	144.000	.429
	Group B	18	1.5	.50		
	Total	36				
Dynamic visual acuity of participants after exercise	Group A	18	.12	.086	69.00	.002
	Group B	18	1.5	.50		
	Total	36				

The Dynamic visual acuity before and after the exercise was taken. The means of the two groups before the exercise were .20 and 1.5 and after the exercise were .12 and 1.5 respectively. The result concluded that there was an insignificant difference between the group before exercise (p-value .429) and a significant difference between the two groups post-exercise. (p-value .002)

Correlation between the fatigue level and Dynamic visual acuity after exercise

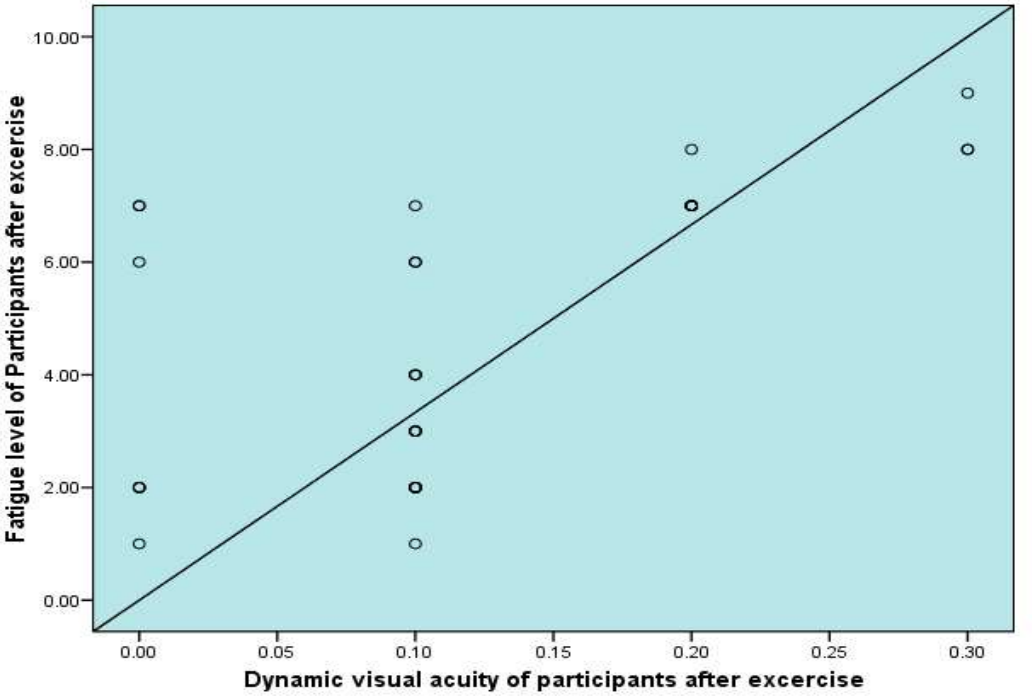
The result showed that Fatigue level and DVA have a significant linear relationship. (r= .678, p-value 0.00). The direction of fatigue level and DVA is positive, i.e. greater fatigue level is associated with greater disturbance in visual acuity. The strength of association is strong i.e. the value of r lies between 0.5-1.0.

Table 5 Spearman's rho correlation b/w fatigue level of patient and DVA after exercise

Co-relation Between Groups		**Dynamic visual acuity of participants after exercise**
Fatigue level of Participants after exercise	Correlation Coefficient	.678**
	Sig. (2-tailed)	.000

** Correlation is significant at the 0.01 level (2-tailed).

Figure 1 Relationship between fatigue level of patient and DVA after exercise



DISCUSSION

The goal of this study was to see how cervical muscle exhaustion affected dynamic visual acuity. 36 people were chosen and divided into two groups. The visual acuity was tested in both the fatigue group and sham exercise group. The result showed that fatigue alters the accuracy of vision. The result was consistent with the previous research, which concluded that increased muscle fatigue affects negatively affects visual acuity and vestibule-ocular reflex (VOR). (Al Saif & Al Senany, 2015). The result also demonstrated a positive correlation between muscle fatigue and dynamic visual acuity. (Pinsault & Vuillerme, 2010). This is because muscle fatigue has been shown to reorientate the emission of the impulses from the receptors present in the neck muscles, which also influence kinesthesia. The disruption in VOR could also be due to a mismatch between three sensory systems. (Rodine & Vernon, 2012). This is probably because neck muscular exhaustion has been linked to altered sensory receptor discharge and altered proprioception as discussed in earlier investigations. The neuronal connections between the three sensory systems may be impacted by neck muscle exhaustion as a result, which may be the primary reason for the gain rise in VOR. One study found no significant difference in visual misapprehension after inducing dorsal muscle fatigue. (Panichaporn, Hiengkaew, Thanungkul, Vachalathiti, & Emasithi, 2013)

Therefore, when evaluating vestibular function in patients with a history of neck pain or trauma, one must take into account that the disturbances in VOR or visual clarity may be due to disturbance in the cervical somatic system leading to impaired visual accuracy. Treatment protocol should include interventions that reduce muscle fatigue or spasms as it has a positive role in causing visual disorientation.

There are certain limitations to this study. The research was carried out on healthy young individuals. Participants of diverse ages should be included. The intervention was applied to the cervical muscles as a whole. There should be a comparison study to investigate which muscle group is mainly responsible for somatosensory disturbances causing visual inaccuracy.

To determine the effects of neck trauma and neck discomfort on visual precision, the study should include instances of neck trauma. Finally, it is important to evaluate how neck muscular exhaustion affects DVA in people who are standing versus those who are seated. So further studies should be conducted to highlight this aspect

CONCLUSIONS

Neck muscle fatigue had a negative impact on visual accuracy in the study**.** Increased muscle fatigue can lead to increased visual misperceptions. The application of these findings suggests that while assessing visual accuracy, the cervical muscles should also be taken into account if there is a history of neck disturbance associated with it. Rehabilitation directed to improve cervical proprioception will lead to increased visual clarity in patients with associated neck muscle fatigue.

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