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Original Research Article

EFFECT OF CERVICAL MUSCLE FATIGUE ON POSTURAL STABILITY

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ABSTRACT

Background: Postural stability is the ability to maintain the body in equilibrium either at rest or in a steady state of motion. Muscle fatigue is the diminished response of muscle to repeated stimulus. Cervical proprioceptive inputs provide important somatosensory information influencing postural stability. Hence, we performed this study to evaluate the effect of experimentally induced fatigue on general cervical musculature on postural stability.

Aim: To study the effect of experimentally induced cervical muscle fatigue on postural stability.

Materials and Methods: 30 subjects who met the inclusion criteria were recruited in the study with their prior consent. Fatigue was induced in the cervical muscles using a pressure biofeedback machine. Postural stability was assessed using Modified CTSIB and Multi-directional Reach test both before and after inducing fatigue.

Results: Postural sway significantly increased post fatigue in all sensory conditions of Mod-CTSIB: EO AP -0.0189, EO lateral p- 0.0001, EC AP p- 0.0223, EC lateral p- 0.0037, FEO AP p- 0.0033, FEO lateral p- 0.0148, FEC AP p- 0.0010, FEC lateral p- 0.0072. Multidirectional reach reduced significantly in all 4 directions post fatigue: MDRT Anterior $p<0.0001$, MDRT Posterior $p < 0.0001$, MDRT Rt lateral $p <0.0001$, MDRT Lt lateral $p <0.0001$.

Conclusion: Cervical muscle fatigue produced a significant disturbance on balance as seen by: Increased sway in Modified CTSIB & Decreased functional reach in Multidirectional reach test.

KEY WORDS: Postural stability, Fatigue, Modified-CTSIB, Multidirectional reach test.

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INTRODUCTION

Postural Control involves controlling the body's position in space for the dual purposes of stability and orientation. It emerges from a complex integration of sensory afferent systems, motor effector systems & CNS integration processes [1].

Postural stability is the ability to maintain the body in equilibrium either at rest or in a steady state of motion or to maintain the center of mass within the limits of base of support. The somatosensory, vestibular & the visual systems are the sub-systems of the postural control system (PCS) [1]. The somatosensory system encompasses all of the mechanoreceptive information from the periphery which leads to perception of pain, temperature, touch & proprioception [2,3].

There is abundance of mechanoreceptors in the muscles and joints of the cervical spine. Thus, cervical proprioceptive information provides important somatosensory information influencing postural stability, head orientation and eye movement control [4].

Muscle fatigue is the diminished response of muscle to repeated stimulus and it is characterized by gradual decline and force producing capacity of the neuromuscular system that is a temporary state of exhaustion leading to decrease in muscle strength [5].

From the available review of literature, numerous studies have reported decreased ability to maintain balance in patients with neck pain and in normals after inducing fatigue in specific group of muscles particularly the trunk extensors, neck extensors and calf. Also, studies have shown decreased ability to maintain balance after inducing general body fatigue.

Cervical muscles being an important contributor to the postural control system, thus the purpose of my study was to evaluate the effect of experimentally induced fatigue on general cervical musculature on postural stability.

MATERIALS AND METHODS

This was an experimental study performed in 2009-2010. The permission to carry out the study was obtained from the ethical committee and all the subjects provided their informed consent. 30 normal subjects were enrolled in the study. Demographic details for the subjects are provided in Table No.1. Subjects with any history of neck trauma, neck pain, whiplash injury, any type of musculoskeletal problems, neurological disease or vestibular impairment were excluded from the study.

Fatigue was induced with the subject lying supine and the deflated pressure cell placed under his sub occipital cervical region. The pressure was increased upto 20mm Hg by inflating the pressure cell. The subject was then asked to perform a chin tuck till the pressure is raised upto 22mm Hg. He was then asked to maintain the pressure rise and hold the chin tuck for 10 seconds without any drop in the pressure. After successfully maintaining the chin tuck for 10 seconds, he was told to relax. Similarly, he was asked to perform a chin tuck again this time increasing the pressure by 2 mm Hg i.e. up to 24 mmHg. He was asked to maintain and hold this position for 10 seconds. In this fashion, after every successful effort of maintaining and relaxation, the subject was told to increase the pressure by 2 mmHg each time. In this way, we got the maximum pressure that the subject could successfully hold for 10 seconds, which implies the strength of his/her cervical muscles. At the subject's maximal pressure, he /she was made to perform repetitions with 10 seconds hold. This procedure was continued until the pressure dropped within the 10 seconds i.e. the cervical muscles had fatigued and could no longer maintain the desirable maximal pressure.

Postural sway was measured using a sway meter which consisted of 40cms rod mounted at subjects waist level posteriorly with a pen attached at the end. The pen was mounted on the graph paper on a height adjustable table. The antero-posterior and lateral sway was measured under the 4 conditions of Modified CTSIB. Postural stability was also assessed with Multidirectional Reach Test in all four directions. All the subjects were assessed with both the tests under two tests conditions: before cervical muscle fatigue and immediately after cervical muscle fatigue. A gap of 1 week was kept in between the two assessments for adequate recovery of muscles.

Table 1: Demographic details.

Sex (male/female)	15/15
Age (yrs)	23±2

Statistical analysis: Wilcoxon Signed Rank test was used for within group comparison between pre and post cervical muscle fatigue of the outcome measures – Modified-CTSIB and Multi-directional reach test. All statistical analyses were performed using SPSS Version 17.A p-value of 0.05 or less was considered statistically significant.

RESULTS

Table. 2 shows the comparison of the pre and post fatigue values of the outcome measures. There was a significant change in all the outcome measures. Postural sway significantly increased post fatigue in all sensory conditions of Mod-CTSIB: EO AP - 0.0189, EO lateral p- 0.0001, EC AP p- 0.0223, EC lateral p- 0.0037, FEO AP p- 0.0033, FEO lateral p- 0.0148, FEC AP p- 0.0010, FEC lateral p- 0.0072. Multidirectional reach reduced significantly in all 4 directions post fatigue: MDRT Anterior p <0.0001, MDRT Posterior p < 0.0001, MDRT Rt lateral p <0.0001, MDRT Lt lateral p <0.0001.

Table 2: Measures pre and post cervical muscle fatigue.

Measures	Pre- fatigue		Post- fatigue		P- value
Mod-CTSIB					
	AP Sway	Lateral Sway	AP Sway	Lateral Sway	
Eyes open firm surface	1.47	1.333	2.053	2.417	AP- 0.0189*
					Lat- <0.0001*
Eyes close firm surface	1.877	1.813	2.36	2.567	AP- 0.0223*
					Lat- 0.0037*
Eyes open foam surface	2.673	2.617	3.6	3.323	AP- 0.0033*
					Lat- 0.0148*
Eyes close foam surface	4.153	3.677	5.197	4.557	AP- 0.0010*
					Lat- 0.0072*
Multi-directional reach test					
Anterior	13.07		11.43		<0.0001*
Posterior	8.033		6.467		<0.0001*
Right lateral	8.533		7.367		<0.0001*
Left lateral	7.65		6.4		<0.0001*

* = P value is significant (P<0.05)

DISCUSSION

Postural control requires complex organization of many senses that are related by the CNS to many muscles that act as multi-linked musculoskeletal system [4]. Afferent information from the muscle spindle of the cervical muscles is of primary importance for cervical proprioceptive acuity and this information is combined with the input from the vestibular and visual systems. The cervical afferents have the following central connections which are required for postural control [5,6].

Fatigue (central and peripheral) is a phenomenon that is influenced by a complex integration of physiological, chemical, sensory and psychological feedback. The factors that contribute to fatigue decrease the muscle force, working capacity and result in an internal perturbation to motor system which produce an impairment in motor co-ordination and postural control [4].

The results from this study have showed a significant decrease in postural stability as seen by increase in postural sway in the conditions of Mod-CTSIB and decrease in the reach in all 4 directions of Multi-directional reach test post cervical muscle fatigue.

Several hypotheses have been postulated to explain decrease in postural stability post fatigue. The factors could be attributed to both peripheral and central means of fatigue.

The first set of explanation for peripheral fatigue could be related to muscle hypoxia post fatigue [7]. Anaerobic glycolytic predominates for the supply of energy post fatigue resulting in imbalance in hydrogen release and the subsequent oxidation causing pyruvate to accept the excess hydrogen ions and thus forming lactic acid which starts accumulating within the muscle. Due to this, there is limitation in energy supply and the efficiency of the cervical muscles to function is impaired [7].

The sensory input from these muscles operates through a proprioceptive chain to maintain postural stability which is disturbed post fatigue leading to instability.

It has been also said that the accumulation of lactic acid after fatiguing exercises lead to firing of group III and IV muscle spindle afferents which are sensitive to metabolites and inflammatory substances accumulated within the muscles. These afferent impulses perceived as an impending injury in the CNS which in turn cause greater inhibition of motor units, decreased firing rate, discharge rate of afferents such as Ia from muscle spindle, Ib from Golgi tendon organ and small diameter afferents as a protective mechanism. This constitutes the Central component of fatigue [6].

Fatiguing effects of declining pH during exercise includes allosteric inhibition of rate limiting enzyme phosphofructokinase and glycogen phosphorylase, decreased release of calcium from sarcoplasmic reticulum, hindering the excitation-contraction coupling process, and reduction in the number and force of muscle cross-bridge activation. Hence, in the absence of the cervical muscle contraction there will be no proprioceptive input to the CNS which may lead to postural instability [4].

Besides the neurological factors, there are also psychological factors which may come into play after inducing fatigue, which guard against the generation of any further motor activity in order to avoid any further fatigue or injury. This may also be a reason for postural instability.

The ability to maintain upright stance in a wide range of situations evidences that postural control system is adaptive to various task parameters of either external or internal origin and can adjust postural responses by changing the relative weighting of sensory inputs. When the availability or the reliability of input from a particular body location decreases, the central nervous system to increase the weighting of input from other locations that provide reliable information for maintaining stable posture [7].

Hence as seen in Table.2, in the absence of vision i.e. Eyes Closed Firm Surface, results showed a decreased postural control following the cervical muscular fatigue as assessed by an increase in postural sway observed in post fatigue than in no fatigue condition. A greater destabilizing effect in postural sway was observed in the Eyes Closed Foam Surface condition when somatosensory information was altered by the compliant support surface as only vestibular system was available for providing the sensory input to maintain balance. One can surmise from this that the effect of fatigue goes beyond the ability to respond to the ongoing somatosensory feedback and extends to one's ability to employ motor strategies in situations of sensory conflict where the vestibular system is the most reliable sensory modality.

Multi-directional reach test simulates the day to day function of an individual. It was performed to find whether fatigue has an impact on the daily functions of the person. As discussed earlier, fatigue of the cervical muscle leads to imbalance. So while performing this test, the person becomes guarded and his extensibility is reduced. Hence, there is a decrease in the reach as seen in the results.

The limitation of this study is that the relative activity of any specific group of muscles was not determined during the fatiguing intervention or when the balance reactions were assessed. If this could have been identified those muscles can be specifically trained to improve balance performance. Also, the present study used equipment that measures sway amplitude in the conditions of CTSIB. An instrument that measures the deviations of Center of Pressure on a force plate would have allowed us to assess sway velocity and its response to Fatigue.

In conclusion, it was found that cervical muscle fatigue produced a significant disturbance on balance as seen by increased sway in Modified CTSIB & decreased functional reach in Multidirectional reach test.

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Conflicts of interest: None

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