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Original Article

Effect Of Vestibular Exercise On Postural Balance And Eye Hand Coordination Among Smartphone Addicted College Students

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ABSTRACT

Introduction: The escalating use of smartphones has led to behavioral addiction, negatively impacting crucial physical functions like postural balance and eye-hand coordination. This study investigated the efficacy of vestibular exercises in mitigating these effects among smartphone-addicted college students, who often exhibit poor posture and impaired balance due to prolonged device use. **Methodology:** Forty college students (18-25 years) with high smartphone usage (≥5 hours daily for over a year) and elevated Smartphone Addiction Scale scores were divided into two groups. The experimental group (n=20) performed vestibular exercises, while the control group (n=20) engaged in general balance exercises. Both groups underwent a four-week intervention, three sessions per week. Postural balance was assessed using the Stork Balance Stand Test (SBST), and eye-hand coordination was measured with the Ruler Drop Test (RDT). **Results:** Both groups showed significant improvements in postural balance and eye-hand coordination post-intervention. However, the experimental group, which underwent vestibular exercises, demonstrated significantly greater improvements in both the SBST (left: 2.0 vs. 1.3; right: 2.25 vs. 1.15) and RDT (left: 4.7 vs. 2.4; right: 5.3 vs. 3.0) compared to the control group. These differences were statistically significant ($P \leq 0.05$). **Conclusion:** Vestibular exercises are a highly effective intervention for improving postural balance and eye-hand coordination in college students addicted to smartphones, showing superior results compared to general balance exercises.

Keywords: Vestibular Exercise, Postural Balance, Eye-Hand Coordination.

INTRODUCTION

Nowadays, addiction not only refers to drug or substance abuse, but it also refers to gambling, internet, games or even smartphones. These also fall under the category of behavioral addiction (Min kwon, 2013). Using smartphone while walking decreases a person's dynamic balance and walking ability. It is considered that accident rates are higher when using a smartphone. In addition, long periods of smartphone use can cause incorrect posture such as forward head posture and rounded shoulder and injuries in surrounding tissues including ligaments. In particular, visual and auditory inattention inevitably occur when walking while using a smartphone. One previous study report that visual inattention can affect postural sways such as static imbalance during simple and dual tasks. (Lee, 2018)

In the last few years, smartphone users have progressively increased worldwide. With increasing use of smartphones, researchers have also enhanced to investigate the musculoskeletal problems associated with the prolonged use of smartphones. Recent studies have shown that smartphones users tend to have pain in the neck and upper limb, and as the time of the smartphone using increases the severity of the symptoms increases. Prolonged use of smartphones leads to musculoskeletal problems due to faulty posture of the user such as forward neck posture, round shoulders or slouched posture. Prolonged forward neck posture can lead to injury to the structure and ligaments of the cervical and lumbar spine. These structural problems caused by faulty posture can also lead to decrease proprioception and so decrease balance ability. The maintenance of balance is essential in the prevention of injuries and this ability depends on proprioceptive input mechanoreceptors in the capsule, ligaments, muscle and tendon, in addition to vestibular and visual input to the central nervous system. This input is used to

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provide the appropriate neuromuscular response. Alterations in any of these inputs would disturb balance and increase the risk of injury. (Doaa Rafat EI Azab, 2017)

Since advances in smartphone technology have transformed this handheld device into an everyday social and /or professional necessity, maintaining an upright posture or walking while talking or texting on the phone are frequently met dual task demands. Texting proved to have a higher detrimental effect on balance, gait and walking behavior in comparison to talking on the phone, increasing the postural sway and decreasing the gait velocity, stride length and cadence. wulan et al. found that texting affected the postural balance both in normal and tandem stance in healthy college students. Strubhar et al. also reported that cellphone texting had an impact both on the reactive balance and on the gait. Their results showed that healthy individuals had more difficulty controlling their center of mass during perturbed stance while texting. This finding may be due to an interference with the participants orientation to the vertical. The standing balance in healthy young individuals was also affected by texting in the study of Goddard et al. Cho et al. reported a decrease in dynamic balance ability during smartphones texting in healthy young individuals (Onofrei, 2020)

Vestibular apparatus is a membranous structure located within the bony labyrinth of the inner ear. It comprises of three semicircular canals and two otolith organs on either side. Vestibular system is one among the first cranial cavity structures to develop in fetal life and plays an indispensable role in regular activities. Human vestibular system consists of 18500 vestibular nerve fibers, which are extensively connected with cortical and subcortical brain structures. It integrates the cortical and subcortical structures and regulates the posture. Further, through the vestibular spinal pathways the postural stability is maintained by vestibular stimulation. Basic function of vestibular apparatus is to maintain equilibrium that is sense of body orientation and motion in the gravitational field (SS, 2019). Vestibular exercises are another type of exercise that is used to manage chronic vestibular dysfunction. Its positive effect on balance is based on neural flexibility mechanisms of the central nervous system and its goal are to enhance visual stability, improve vestibular visual interaction during head movements, thereby improving static and dynamic postural stability in the situations where they produce inconsistent sensory information and reduce sensitivity to the head movements. (Amir Hamzeh Sabzi, 2019)

The vestibular system is a sensory system that is responsible for providing our brain with information about motion, head position and spatial orientation; it is also involved with motor function that allows us to keep our balance, stabilize our head and body during movement, and maintain posture. Thus, vestibular system is for normal movement and equilibrium. The vestibular system's main function is to sense head movements, especially involuntary ones, and counter them with reflexive eye movements and postural adjustments that keep the visual world stable and keep us from falling. (Maha Abd Ellatif, 2021) Eye hand coordination refers to the integrated use of vision, arms, hand and fingers to accomplish goal directed hand movements. Postural control is the ability to control the centre of mass in relation to the base of support. It depends on the integration of proprioception, vision and vestibular cues in the central nervous system. Vestibular input is particularly important for postural control in sensory challenging environment (William W.N. Tsang, 2014).

METHODOLOGY:

STUDY DESIGN: Experimental study. STUDY SIZE: 40 participants were divided into two groups, 20 in group A (experimental group) and 20 in group B (control group). STUDY DURATION: 4 weeks. STUDY SETTING: Vels school of physiotherapy, Thalambur. STUDY POPULATION: college students. SAMPLE SELECTION: INCLUSION CRITERIA: AGE GROUP: 18 to 25, GENDER: Both male and female, DURATION OF SMARTPHONE USAGE: minimum smartphone usage of 5 hours per day for past 1 year. SMARTPHONE ADDICTION SCALE (SAS) QUESTIONNAIRE: SAS score greater than 106 (high). EXCLUSION CRITERIA: Individuals involved in drug/alcohol abuse. Under any kind of medication. Mental disorder. Vestibular disturbances. Visual problems**.** Ear infection**.** Reported dizziness**.** Recent ankle or knee injury or pain**.** Neurological or musculoskeletal disorders**.** Recent surgical operation

in the lower limbs**.** OUTCOME MEASURES: Stork Balance Stand Test, Ruler Drop Test, Smartphone Addiction Scale.

PROCEDURE:

Individuals were explained about the procedure and were selected according to the inclusion and exclusion criteria. Informed consent was taken from all the subjects who participated in this study. Totally 40 patients were taken and divided into two groups with 20 in each group. Among them group A (experiment group) patients were assigned to follow vestibular exercise and group B (control group) patients were assigned to follow general balance exercise. Patients were asked to participate in this given protocol three times a week for four consecutive weeks. **PRE TEST:** These groups A and B were assessed for postural balance using stork balance stand test and for eye hand coordination using ruler drop test. **POST TEST:** In the end of the study these groups A and B were again assessed for postural balance using stork balance stand test and for eye hand coordination using ruler drop test.

GROUP A (EXPERIMENTAL GROUP)

VESTIBULAR EXERCISE: Each session of exercises comprises of 50 minutes. Three sessions per week was administered to the participants for a period of one month.

Standing upright: The participants were asked to stand upright with feet together and hold that position for 30 seconds. **Single leg stance:** The participants were asked to stand with feet hip-width apart and their weight equally distributed on both the legs, placing hands on their hip, they were asked to lift their left leg off the floor and bend it back at the knee and hold that position for 30 seconds. **Weight shift:** Same as static standing, except feet are in a split stance with one foot forward and one foot backward. The patients were asked to move the body forward and backward, shifting weight from one foot to other. **Sit to stand:** The patient were asked to sit on the edge of the chair, feet hip – width apart. Leans slightly forward and standup slowly, using their legs not arms. Then Stand upright before slowly sitting down. **Rotate 360 degree and then sit**: The patients were asked to sit in a chair with their back away from the back support and then asked to shift their weight forward and then standup straight, turn around 360 degrees standing in the same place and then sit. **Yaw head turns:** The patient were asked to walk forward feet apart, by rotating their head towards right shoulder and left side for 20 times and then asked to repeat the same procedure in backward ambulation. **Pitch head turns:** The patients were asked to walk forward with feet apart by doing head turns forward and backwards for 20 times. **Tandem head still:** The patient were asked to walk forward keeping head still in a straight line, where the toes of the back foot touch the heel of the front foot at each step for 20 feet and then asked to repeat the same procedure in backward ambulation for 20 feet. **Feet apart head still:** The patient were asked to walk keeping head still in a straight line with feet apart for 20 feet. **Shoulder shrugging and circling:** Sitting in a chair the patient were asked to lift both shoulders up towards their ears, then circle them back and down returning to starting position and repeat it for 20 times. **Bending forward and picking up objects from the ground:** Sitting in a chair the patient were asked to bend forward and pick the object from the floor and then return back to the upright sitting position and repeat it for 20 times. **Bending side to side and pick up objects from the ground:** Sitting in a chair the patient were asked to bend side to side and pick the object from the floor and then return back to the upright sitting position and repeat it for 20 times. **Bending forward and backward to touch chin to chest:** Sitting in a chair with face straight ahead the patients were asked to lower their chin to chest and then to bend backward fully and then repeat the same for 20 times. **Moving head 45 degrees to left and right:** Sitting in a chair the patient were asked to turn their head to 45 degrees left and then to right for 20 times. **Moving head 90 degrees to left and right:** Sitting in a chair the patient were asked to turn their head to 90 degrees left and then to right for 20 times.

GROUP B (CONTROL GROUP)

The control group were asked to perform the given general balance exercise thrice a week 40 minutes per day for a period of one month. The general balance group performed the following exercise. **Marching forward:** The patients were asked to march forward for 20 feet and asked to repeat the same for 20 times. **Marching backward:** The patients were asked to march backward for 20 feet and asked to repeat the

same for 20 times. **Marching sideways:** The patients were asked to march sideways for 20 feet and asked to repeat the same for 20 times. **Standing still flexing and extending elbow:** Standing in a place patients were asked to flex and extend the elbow for 20 times. **Hip extension and abduction:** Standing in a place patient were asked to extend the hip and abduct the hip for 20 times. **Stepping sideways with arm swing:** The patients were asked to step sideways by doing arm swing for 20 feet and asked to repeat the same for 20 times. **Walking on the spot:** Standing in a place the patients were asked to march on the spot for 5 mins.

DATA ANALYSIS:

OUTCOME MEASURES	SIDES	MEAN ± SD GROUP A	MEAN ± SD GROUP B	DF	T Value	P Value
SBST	**LEFT**	2 ± 1.3	1.3 ± 0.73	38	2.1	0.04
	RIGHT	2.25 ± 1.12	1.15 ± 0.67	38	3.77	0.00
RDT	**LEFT**	4.7 ± 1.13	2.4 ± 0.68	38	7.8	0.00
	RIGHT	5.3 ± 1.13	3 ± 0.79	38	7.45	0.00

Table 1 - Inter Group Analysis Of All Outcome Measures

DISCUSSION

The present study designed to find the effects of vestibular exercise on postural balance and eye hand coordination among smartphone addicted college students for four weeks. It is observed that postural balance and eye hand coordination is significantly improved in vestibular exercise group A (experimental group), a significant difference was found on both experimental group (vestibular exercise) and control group (general balance exercise) in pre and post test. According to the results of the data analysis both the groups are significantly improved, but comparatively group A shows more significant values than group B.

On comparing Pre test and Post test within Group A & Group B on Stork Balance Test (Left & Right) Score & Ruler Drop Test Score shows highly significant difference in mean values at $P \leq 0.05$. The main goal of the study is to find the effect of vestibular exercise on postural balance and eye hand coordination among smartphone addicted college students.

Mansoori M H, et al stated that vestibular rehabilitation might provide the necessary stimuli for reorganization and central sensory integration, thus it enhance proper body postural control through three mechanisms of replacement, adaptation and habituation. such a measure allows the brain to maintain balance with signals coming from the inner ear, as well as relying on signals initiating from the eyes, knees, leg and neck to improve balance. The CNS processes input signals and integrates those with other sensory information to estimate head awareness. In this case, the output of the central vestibular system are transmitted to ocular muscles and the spinal cord producing two major ocular-vestibular and spinal vestibular reflexes which activates antigravity muscles, i.e.,extensors and inhibits flexor muscles. Thus, it plays an important role in creating appropriate postural responses and movement strategies in organs, such as ankle, thigh and leg (Mansori, 2020). smartphone use has been increased in teenage students life, they use it for participating on social media, entertaining, searching and learning. Until recently, the effects of prolonged smartphone use on motor skills like hand eye coordination, dexterity and strength were largely unknown (Mohamed, 2022). Postural stability was significantly affected by talking and texting on a smartphone in healthy young adults. They had more difficulty maintaining standing postural balance while talking on the phone than when texting (Onofrei, 2020). Smartphone users are vulnerable to having severe musculoskeletal disorders as the duration of using increased, the symptoms of

which can include fatigue and pains in the upper extremities. Such as the neck, shoulders, arms, wrists, back of the hands and fingers. Repeated static motion of the users decreases blood circulation, prevents nutrients from being supplied to muscles and lead to small amount of pain and fatigue. In addiction poor posture leads to fatigue, which can have negative effects, such as reduced physiological function, disruption of the autonomic nervous system, creation of problems in daily life and affects both the visual and the musculoskeletal systems, leading to head aches and stress. One study concluded that neck pain and muscle tension can change sensitivity of neck proprioception, which affect dynamic balance ability. Schieppati et al., stated that fatigue of cervical muscular affects balance. The first explanation was that balance is controlled by the CNS through the integration sensory information from the vestibular, somatosensory and visual systems and when the muscles at control balance are fatigued, these system would be affected, thus inhibiting proper balance control. Second explanation, muscle fatigue enhances the muscle spindle discharge, which obstructs the afferent feedback input to CNS that causes alterations in proprioceptive and kinesthetic properties of joints, which has negative effect on postural control ability (Doaa Rafat EI Azab, 2017). Stimulation of vestibular system through exercise triggers the sensory conflicts that cause adequate stimulation of the structures involved in the maintenance of posture and improves the stability. Further, it was reported that vestibular stimulation integrates the cortical structure through its connections and helps to overcome postural difficulties and it integrates the midbrain structures like inferior colliculus, interstitial nucleus and periaqueductal gray matter maintain the balance (SS, 2019).

On comparing the Mean Values of Group A & Group B on Stork Balance Test (Left & Right) Score, it shows a significant increase in the post test mean values in both groups, but (Group A - Vestibular Exercises) shows 2 (Left) & 2.25 (Right) which has the higher mean value is more effective than (Group B - Control) 1.3 (Left) & 1.15 (Right) at $P \leq 0.05$. On comparing the Mean Values of Group A & Group B on Ruler Drop Test (Left & Right) Score, it shows a significant increase in the post test mean values in both groups, but (Group A - Vestibular Exercises) shows 4.7 (Left) & 5.3 (Right) which has the higher mean value is more effective than (Group B - Control) 2.4 (Left) & 3 (Right) at $P \leq 0.05$. On comparing Pre test and Post test within Group A & Group B on Stork Balance Test (Left & Right) Score & Ruler Drop Test Score shows highly significant difference in mean values at $P \leq 0.001$. Thus, it was evident from the test, group A (Experimental group) shows high significant difference in mean values than group B (control group)

CONCLUSION

The study found the effect of vestibular exercise on postural balance and eye hand coordination among smartphone addicted college students. The results of the study shows that both group A(experimental) and group B(control) are significantly improved, but the experimental group A (vestibular exercise) shows higher mean value on stork balance test and lower mean value in ruler drop test, which is more effective than control group B. Hence the study concluded that group A shows high significant difference and statistically improved than group B.

LIMITATIONS AND RECOMMENDATION

This study is limited in terms of the sampling method used, which may limit the generalization of the results. The study population was healthy individuals. The sample size of the study was small. There was no follow-up to check the sustaining effects of interventions. The duration of the study was 4 weeks. Research samples were only obtained from one location. The intervention can be given for longer duration for more effective results. The study can be done with larger Samples. In further studies follow up can be done for checking the sustaining effect of intervention.

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