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Managing Forward Head Posture: Role of VR Gaming and Proprioceptive Training in Neck Pain and Proprioception

Vaishnavi Giridharan[1]*, Majitha Parveen[2], Kamatchi Kaviraja[1], Eliza Giftson Titus Elumalai[3], Elakkiya Rajaram[1], Ijaj Rahman[1] and Elavarasan Kumar[1]

[1]Faculty of Physiotherapy, Dr. MGR Educational and Research Institute, Chennai, Tamil Nadu, India.
[2]Department of Physiotherapy, Physiotherapy Center, Chennai, Tamil Nadu, India.
[3]Department of Physiotherapy, Annaii Medical college and Hospital, Chennai, Tamil Nadu, India.
*Corresponding Author E-mail: vaishnavi.physio@drmgrdu.ac.in

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The goal of this study is to assess the effectiveness of Virtual Reality Game-Based Exercise and Proprioceptive Training in addressing neck pain and enhancing neck proprioception in students with forward head posture. Forward head posture is a prevalent position adopted by many individuals due to their frequent use of computers or smartphones. This condition involves the forward positioning of the head, which contributes to an increase in cervical lordosis and thoracic kyphosis. Proprioceptive input from the neck muscles is crucial for maintaining postural control. This forward head posture affects proprioceptive feedback from the neck muscles and results in deficits in postural control as well as neck pain. An experimental study was carried out on individuals with forward head posture. A total of 30 participants were chosen based on specific selection criteria, with a pre-test conducted using the Joint Position Error Test to assess neck proprioception and the visual analogue scale to measure neck pain. Treatment was administered over a period of 8 weeks, five days a week. The 30 participants were split into two groups, each consisting of 15 individuals. Group A participated in Virtual Reality Training, which included interventions for neck pain lasting 25 minutes and neck proprioception lasting 20 minutes, while Group B engaged in Proprioceptive Training for both neck pain and neck proprioception, consisting of CJPS for 10 minutes, cervical motion sense for 10 minutes, gaze stability for 10 minutes, and a swiss ball stabilization exercise for 15 minutes. When analyzing the data between Group A and Group B, both groups showed significant differences between the pre-test and post-test results. However, Group A exhibited a more pronounced significance than Group B. Hence Virtual Reality Game Based Exercise was more effective than Proprioceptive Training on treating neck pain and neck proprioception among patients with forward head posture.

Keywords: Forward Head Posture; Joint Position Error Test; Neck Pain; Proprioception; Proprioceptive Training ; Virtual Reality.

The need for usage of smartphones and laptops are increasing day by day among the students, there is a lack of awareness of head position while using mobile phones and laptop. Due to this there is a change in the head position which causes stress on the neck muscles which leads to pain, discomfort and loss of proprioception sense.

To minimise the impact of muscular activity and to lessen the strain on the muscles surrounding the neck, the ideal head position

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is necessary. Numerous individuals who spend long hours on computers and mobile devices may display alterations in their head position.The most typical posture, which results in Forward Head Posture (FHP), is the flexed neck position. The forward displacement of the head with respect to the shoulder is known as forward head posture. In practically every group, this posture is analysed in the sagittal plane with varying degrees of severity. More forward head position has been linked to larger deficits in neck cervical motions, specifically neck rotation and flexion.[1] It has been proposed that forward head posture, which is frequently linked to neck pain, increases the strain on the posterior cervical elements, alters the length-tension relationship in the neck muscles, increases muscular activity, restricts neck movements, and impairs cervical proprioception.[2]

Under normal circumstances, the head's centre of gravity is located in front of the atlanto-occipital joint, which stabilises or keeps the head in a neutral position with the least amount of muscular effort. In contrast, a forward head posture causes the head to tilt forward in the sagittal plane with respect to the trunk, which increases muscle activity, particularly at the back of the neck. Both the deep and superficial neck stabilising muscles are less active when the head is positioned forward.[3] Because there is less dispersion of biomechanical strain in this posture, the neck muscles degenerate and undergo structural alterations.

There is a compensatory change in spinal curve like rounded shoulder and abnormal muscle activity is observed. The deep cervical flexors and scapular retractors are weakened, resulting in tension and thickness in the sternocleidomastoid. The abnormal responses of hyperactivity and muscle inhibition serve as protective reactions to either prevent bodily harm or alleviate pain.[4]

According to the report, prolonged use of this position can shorten muscle fibres and reduce the amount of sarcomeres, both of which may affect how well muscles contract.[5]

The capacity to sense how different bodily parts move and arrange themselves in relation to one another without the aid of vision, touch, or the organs of balance was defined by Sherrington in 1906.[15] Proprioception, which gives the nervous system sensory feedback from the body, aids in maintaining ideal body alignment. Information is relayed to the central nervous system by receptors such as parcinian corpuscles and ruffini receptors. The receptors in muscle are called muscle spindles plays a vital part in proprioception. Because the cervical muscle contains a large number of mechanoreceptors, the cervical area is thought to be crucial for information transmission.[6]

A key component of postural regulation is the proprioceptive sense. It works in tandem with vestibular system sensing to respond sensitively to subtle head movements. Head and neck misalignment causes information to be received incorrectly, which impairs balance and raises the risk of falling.[7] Proper body orientation, balance control, head-in-space, and trunk orientation are all aided by cervical proprioception. Long-term strain on the cervical joints disrupts the signals that go to the brain, which may lead to issues with balance and neck proprioception.[8]

The cervical muscles has a larger distribution of muscle spindles rather than any other muscles, the suboccipital muscles has many muscle spindles per unit, indicates that it requires a high proprioceptive function.[9] Proprioception is necessary for joint proper function during exercises, helps with motor control and increases muscle stiffness which provide joint dynamic stability. The limitation of functional mobility is due to the loss in proprioception feedback. The density of the mechanoreceptor is more in deep muscles of the neck than superficial muscles. Due to forward head posture the superficial muscles becomes short and deep muscles become long and weak.[10]

A musculoskeletal condition called neck discomfort is brought on by bad posture and might affect one's ability to move or operate.[11] Increase in the usage of electronic gadgets like smartphones and laptops has been found to increase in the neck pain among the students. The use of these devices causes the user to hold their head still for extended periods of time, which strains the neck muscles and causes pain and discomfort.[(12)] The common musculoskeletal condition known as neck pain is marked by soreness or discomfort in the area between the T1 and the inferior edge of the occipital bone.[13] Because they are less conscious of their posture and do not know the proper working positions, those who use computers, work in offices, or are students are more likely to experience neck pain.[14]

Since forward head position is thought to be a risk factor for neck pain, research on the strength and function of the neck muscles in people with forward head posture may help lower the prevalence of neck discomfort.[16] Motor dysfunction, incapacity, and chronic pain are the side effects of neck discomfort. Patients with persistent neck pain have reported muscle weakness, exhaustion, and morphological abnormalities, which may impact the stability of the cervical spine and the function of mechanoreceptors. Cervical position sensing dysfunction is thought to be caused by impairments in muscle and mechanoreceptor function[17]

Many interventions and exercise protocols are introduced for the posture correction, neck pain management and for increasing proprioception. Exercise interventions like deep cervical muscle strengthening, isometrics, postural education are postulated for the management of neck pain, proprioception deficit and posture. Recently virtual reality programme technique has promising effect on many field and management of pain. Virtual reality is used in field of treatment and rehabilitation.

One method that shows promise for training cervical kinematics is the use of virtual reality. Virtual training has several benefits, such as diverting attention, which lessens kinesiophobia and pain, encouraging physical activity, and increasing the efficacy of exercise.[18] Through the use of computer software, virtual reality presents the virtual environment. The image is shown to the user on a head-mounted display. The idea of immersion is used in virtual reality, which enables the VR environment to divert the patient. When the immersion property is high, the user's focus is on the virtual environment, diverting them from other things, such as discomfort. VR is a nonpharmacologic analgesic that modifies the complex pain regulation system in the body.[19]

Programs that use virtual reality encourage motivation and enjoyment, which encourages patients to freely engage in their therapies.[20] Immersion, interaction, and simulation are the three fundamental components of virtual reality. Through the perception of visual, aural, tactile, or kinaesthetic cues in a virtual environment, the patient is able to engage in intuitive interaction. As a result, VR therapy provides more feedback, making it a pain-distracting method. Because of its versatility and distracting element, immersive virtual reality can be utilised with people who have neck pain.[21]

VR, a crucial aspect of motor control that is thought to be crucial in the chronicity and recurrence of some orthopaedic illnesses, can be used to evaluate the integration between the neurocognitive and musculoskeletal systems.[22] In order to improve their score and avoid boredom, patients play the therapeutic game often. The key component of motor learning is feedback, which is also a common factor in virtual worlds.[23]

Proprioceptive training includes fine control of neck movement via the suboccipital muscles, spatial orientation of voluntary movement, and modulation of muscle tone. Enhancing cervical proprioception and motor control is the ultimate aim of proprioceptive training. Proprioceptive training reduces neck discomfort and impairment by strengthening the craniocervical flexors, enhancing cervical proprioception, and improving neuromuscular coordination.[24] It has been demonstrated that the proprioception program, which includes exercises for gaze stability, eye-head synchronisation, and practicing head displacement on the trunk, improves joint position error.[25]

Craniovertebral angle (CVA) was used to measure the forward head position. It is the angle formed by a line that spans the seventh cervical vertebra's spinous process (C7) and connects the tragus of the ear.[26] The average CVA for males in the 22–44 age range is 48.8 degrees, whereas the average CVA for females in the 23–66 age range is roughly 47.6 degrees. A CVA of 49.9 degrees is considered normal.[27] Those who experience cervical pain have a CVA below 45 degrees; the lower the CVA, the higher the FHP.[28]

Joint position error tests (JPET), which are commonly used to detect proprioceptive dysfunction in the cervical region, have been linked to the frequency of neck discomfort. The proprioceptive functioning of the head and neck is reflected in joint position error measures. Patients with neck pain had values greater than 4.5 degrees.[29]

The capacity to move the head to a starting or normal head posture while closing the eyes is known as cervical joint position error. It was discovered that the laser approach to measuring JPET showed a strong correlation and good test-retest repeatability.[30] Visual Analogue Scale (VAS) is normally an horizontal line 10cm long with one end predicting strong pain and other predicting absence of pain. Subjects marks the intensity of the pain in the scale.[31]

The objective of this current study aims is to evaluate the effectiveness of Virtual Reality Game Based Exercise and Proprioceptive Training on neck pain and neck proprioception in patients with forward head posture among students.

MATERIALS AND METHODS

The methodology employs a experimental comparative study and was carried out with the approval by the ethics committee of institution's review board, Faculty of Physiotherapy, Dr.MGR Educational and Research Institute with the letter numbered IRB REF NO: MPT /PHYSIO/ IRB/2024. Participants were provided with informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research procedures adhered to the guidelines outlined in the updated Helsinki Declaration from 2008, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

Procedure

Based on the selection criteria, 30 participants randomly selected using lottery method with forward head posture were chosen and split into two groups .Sample size was calculated using G*power 3.1.9.4 software with level of significance at 5% and power at 90% with n=30. The subjects were male and female, and their ages ranged from 18 to 26, subjects who had craniovertebral angle below 45 degrees, subjects who indicated 6-8 in Visual Analogue Scale, subjects who scored more than 7 cms or more than 4.5 degrees in Joint Position Error Test were included in the study. Informed consent was received from all the participants. Subjects with recent injury to cervical spine, subjects with abnormal vision and any neurological disorder were excluded from the study. The forward head posture is measured by examining the craniovertebral angle using "On protractor app". The selected subjects undergone pre- test by using "Joint Position Error Test" for cervical proprioception sense, "Visual Analogue Scale" for neck pain. In each group 15 subjects was assigned. Group A was virtual reality training group, interventions for both neck pain and neck proprioception was given, the duration of the treatment for neck pain was 25 minutes and for neck proprioception was 20 minutes. Group B was proprioceptive training group, intervention for both neck pain and for neck proprioception was given, intervention protocol includes cervical joint position sense for 10 minutes, cervical motion sense for 10 minutes, gaze stability for 10 minutes and swiss ball stabilisation exercise for 15 minutes with 3 sets and 5 repetition with rest periods of 2 minutes.

Intervention

For ten minutes, each participant in both groups underwent warm-up exercises that included static stretching and active range-of-motion exercises for the shoulders and neck. Static neck stretches for five minutes are part of the cool-down exercises.

Group A: (virtual reality training)

Virtual reality training was given by using Oculus Gear VR with controller. Two types of games were implemented which aims to improve neck proprioception and to decrease neck pain.

VR ABYSS Sharks & Sea Worlds

Position of patient: Sitting upright with back supported and head in neutral position.

This game was given for neck pain. In this game the subject wears the VR Goggles and dives into the water and collects different objects like coins and bottles to get high score by turning his head in all directions. The subjects plays the game for 25 minutes with rest period of five minutes.

VR Thrills

Position of patient: Sitting upright with back supported and head in neutral position.

In this the game the subject wears the VR Goggles and travels along with roller coaster and turns his head accordingly that helps the subject to improve their neck proprioception. The subjects plays the game for 20 minutes with rest period of five minutes.

Group B: (Proprioceptive training)

Cervical Joint Position Sense

In the first and second weeks, CJPS used laser-assisted feedback to shift their heads back to neutral head posture after engaging in active neck movement (flexion, extension, rotation, and lateral flexion) while keeping their eyes open.During third and fourth week, patient is instructed to move their head until the laser beam was aimed on the point, and then to close their eyes and memorize their head- neck position for 5 sec. Maximal movement of head was performed in one direction (flexion, extension, lateral flexion, rotation), after which the patients tried to recover their initial head position as closely as possible, and opened their eyes. During fifth and sixth week, exercise done with eyes closed. During seventh and eighth week, same exercise done during fifth and sixth week was continued. Exercise was given for 3 sets of 5 repetition to all weeks with rest periods of 2 minutes. Exercise was given for 10 minutes.

Cervical motion sense

The cervical movement sense activities for the first and second weeks required the participant to trace a line with laser feedback in both a vertical and horizontal plane while keeping their eyes open. The exercise advanced to gently tracing a figure of eight with laser feedback in the third and fourth weeks. The exercise advanced to tracing a figure of eight with laser feedback at a faster pace in weeks five and six. During seventh and eighth week, same exercise done during fifth and sixth week in continued. Exercise was given for 3 sets of 5 repetition to all weeks with rest periods of 2 minutes. Exercise was given for 10 minutes.

Gaze stability

In the first and second weeks, the head remains motionless (horizontal or vertical) as the eyes track a target on the outstretched palm at a leisurely pace. The patient moves their head and fixes their gaze on a vertical or horizontal target during the third and fourth weeks. The patient moves their head and eyes in unison on a vertical or horizontal target during weeks five and six. During seventh and eighth week, same exercise done during fifth and sixth week in continued. Exercise was given for 3 sets of 5 repetition to all weeks with rest periods of 2 minutes. Exercise was given for 10 minutes

Outcome

Joint position error test

Joint Position Error Test was done by placing a laser light mounted helmet on head. The patient was asked to sit with a back support and foot placed on the floor with hip and knee at 90 degree. The target paper was fixed on the wall about 90 cms away from the subject's position. The subject was asked to fix his head at the centre of the target paper, then asked to move his/her head in all four directions to the right, left, upward, downward and bending on right and left side and return to the beginning point with eyes closed. The point where subjects reached in all six directions were detected and measured the distance between the starting point and detected point. The normal relocation is within 7 cms or less than 4.5 degrees (horizontal) from the starting point more than 7 cms or 4.5 degrees is considered as abnormal error. Thus an approximately 7.1 cms error distance indicates meaningful error.

Craniovertebral angle

CVA was assessed to find out the forward head posture. CVA was measured using "ON PROTRACTOR" smart phone application using One plus 8 pro mobile. Subjects seated in a comfortable position with hip and knee at 90 degree and The individual was told to fix their attention on a specific spot at eye level. A horizontal line that extended from the tragus of the ear to C7 and ran through the C7 spinous process was used to assess CVA. Angle that created between them was measured.

Data analysis

Both descriptive and inferential statistics were used to tabulate and evaluate the gathered data. Version 24 of the statistical package for social science (SPSS) was used to evaluate each parameter. The independent t-test, also known as the student t-test, was used to determine the statistical difference between the groups, and the paired t-test was used to determine the statistical difference within the groups.

RESULTS

There is a significant difference between the pre-test and post-test values for the joint position error test (cervical flexion) between the pre-test and post-test mean values of group A (11.533 and post-test 9.633 mean value) and group B (12.067 and post-test 11.300 mean value). However, the post-test value has improved, which is highly significant when compared with the pre-test at P d" 0.05.

There is a significant difference between the pre-test and post-test values for the joint position error test (cervical extension) between the pre-test and post-test mean values of group A (pre-test 12.933 and post-test 10.420) and group B (pre-test 13.700 and post-test 12.767). However, the post-test value has improved, which is highly significant when compared with the pre-test at P d" 0.05.

There is a significant difference between the pre-test and post-test values for the cervical right lateral flexion joint position error test (pre-test = 11.633 and post-test = 9.867 mean value of group A and pre-test = 12.800 and post-test = 11.933 mean value of group B). However, the post-test value has improved, which is highly significant when compared with the pre-test at P d" 0.05.

There is a significant difference between the pre-test and post-test values for the cervical right lateral flexion joint position error test with the

Table 1. Comparison Of Joint Position Error Test (Cervical Flexion) Between Group -A and Group - B In Pre And Post Test

#JPET	#Group - A		#Group - B		t - TEST	df	Significance
	Mean	S.D	Mean	S.D			
PRE TEST	11.533	2.6824	12.067	1.7512	-.645	28	.524
POST TEST	9.633	2.2077	11.300	1.8008	-2.266	28	.031**

Table 2. Comparison Of Joint Position Error Test (Cervical Extension) Between Group - A and Group - B In Pre And Post Test

#JPET	#Group - A		#Group - B		t - TEST	df	Significance
	Mean	S.D	Mean	S.D			
PRE TEST	12.933	3.5298	13.700	1.2649	-.792	28	.435*
POST TEST	10.420	2.8151	12.767	1.4376	-2.875	28	.008**

Table 3. Comparison Of Joint Position Error Test (Cervical Right Lateral Flexion) Between Group - A And Group - B In Pre And Post Test

#JPET	#Group - A		#Group - B		t - TEST	df	Significance
	Mean	S.D	Mean	S.D			
PRE TEST	11.633	4.517	12.800	4.300	-.724	28	.475
POST TEST	9.867	4.0420	11.933	4.135	-1.384	28	.177

Table 4. Comparison Of Joint Position Error Test (Cervical Left Lateral Flexion) Between Group - A And Group - B In Pre And Post Test

#JPET	#Group - A		#Group - B		t - TEST	df	Significance
	Mean	S.D	Mean	S.D			
PRE TEST	12.727	4.3251	13.600	3.6164	-.600	28	.553
POST TEST	10.800	3.5996	12.600	3.4651	-1.395	28	.174

Table 5. Comparison Of Joint Position Error Test (Cervical Right Rotation) Between Group - A And Group - B In Pre And Post Test

#JPET	#Group - A		#Group - B		t - TEST	df	Significance
	Mean	S.D	Mean	S.D			
PRE TEST	14.433	3.5044	15.233	3.2506	-.648	28	.522
POST TEST	12.333	3.2714	14.333	3.1997	-1.693	28	.010**

Table 6. Comparison of Joint Position Error Test (Cervical Left Rotation) Between Group – A and Group – B in Pre and Post Test

#JPET	#Group - A		#Group - B		t - TEST	df	Significance
	Mean	S.D	Mean	S.D			
PRE TEST	11.767	4.5703	14.600	3.3015	-1.946	28	.062
POST TEST	9.867	4.0641	13.467	3.1252	-2.720	28	.011**

Table 7. Comparison of Visual Analogue Scale Score Between Group– A and Group – B in Pre and Post Test

#JPET	#Group - A		#Group - B		t - TEST	df	Significance
	Mean	S.D	Mean	S.D			
PRE TEST	6.80	0.775	7.00	0.756	-0.716	28	.480
POST TEST	4.53	0.640	5.33	0.617	-3.485	28	.000**

post-test value showing improvement that is highly significant when compared with the pre-test at P d" 0.05. The pre-test mean value of group A was 12.727 and the post-test mean value was 10.800, while the post-test mean value of group B was 13.600 and the post-test mean value was 12.600.

There is a significant difference between the pre-test and post-test values for the cervical right rotation jpint position error test (pre-test 14.433 and post-test 12.333 mean value of group A and pre-test 15.233 and post-test 14.333 mean value of group B). However, the post-test value has improved, which is highly significant when compared with the pre-test at P d" 0.05.

There is a significant difference between the pre-test and post-test values for the cervical left rotation joint position error test (pre-test mean value of 11.767 and post-test mean value of 9.867 for group A and 14.600 and post-test mean value of 13.467 for group B). However, the post-test value has improved, which is highly significant when compared with the pre-test at P d" 0.05.

There is a significant difference between the pre-test and post-test values on the visual analogue scale for group A (pre-test 6.80 and post-test 4.53 mean value) and group B (pre-test 7.00 and post-test 5.33 mean value). However, the post-test value has improved, which is highly significant when compared with the pretest at P d" 0.05.

When Group A and Group B's data analysis is compared, both groups exhibit significant differences between the pre-test and post-test. However, there is a significant difference between Group A and Group B. Therefore When it came to treating neck discomfort and neck proprioception in patients with forward head position, virtual reality game-based exercise outperformed proprioceptive training.

DISCUSSION

Optimal head position is required to minimize the effect of muscular activity and to reduce stress on the muscles surrounding the neck.

Changes in head position may be noted in many individuals using mobile phones, computers for the long time. The most common position is neck in flexion leading to forward head posture. The changes in the head position causes stress on the neck muscles which leads to pain, discomfort and loss of proprioception sense.

The current study examined how well virtual reality game-based exercise (Group A) and proprioceptive training (Group B) reduced neck pain and improved cervical proprioception in participants aged 18 to 26 who met the inclusion/exclusion criteria and had forward head posture (craniovertebral angle < 45°, VAS 6–8, and elevated Joint Position Error). According to the Visual Analogue Scale (VAS) and the Joint Position Error Test (JPET), all groups had similar baseline levels of neck pain and decreased proprioception before to the intervention.

Main Findings & Relation to Objectives

Both treatments resulted in improvements in proprioceptive accuracy and statistically and clinically significant decreases in neck discomfort. Notably, compared to those receiving conventional proprioceptive training, participants in Virtual Reality Game-Based Exercise saw more noticeable improvements in JPET and larger decreases in VAS scores. These results are consistent with the main goal of the study, which was to determine whether virtual reality-based strategies may improve the management of deficiencies associated with forward head posture.

Interpretation & Comparison With Other Studies

Virtual reality-based interventions are more effective because they are immersive and engaging, which probably improves adherence, motor learning, and the integration of sensory feedback. These findings are in line with new research in musculoskeletal rehabilitation, which showed that VR therapies outperform traditional modalities in reducing pain and improving joint position awareness. Proprioceptive training has been shown to be effective in improving cervical sensory-motor function, as seen by the positive outcomes.

Rezaei I. et al.[23] their study result concluded that both virtual reality (VRT) and conventional proprioceptive training (CPT) protocols help people with chronic neck pain achieve better dynamic balance and less pain and disability. Analysis between groups showed that VRT was superior to CPT in lowering disability and pain.[23]

Madhumanti Mukherjee et al.[19] concluded that participants with cervical spondylosis experienced less discomfort and improved cervical ranges when using both traditional and virtual reality training techniques. However, VRT reduces pain more effectively than traditional treatment alone. It has been demonstrated that the primary mechanism underlying pain alleviation with VRT is distraction.[19]

Marina Nusser et al.[18] claimed that the patients' headaches and neck pain significantly improved in the VR group. Analyses conducted between groups showed that the extra VR training improved headaches and active cervical range of motion in both flexion and extension more than the other groups. Compared to the same training using a laser point affixed to the participant's head, VR training reduced discomfort more successfully.[18]

Hyo Jin Yoo et al.[25] stated that neck posture correction exercises paired with kinesio taping or proprioceptive training are effective interventions for addressing neck disability, craniocervical angle and muscle activity than performing the neck posture correction exercises alone. The results of the study shows that neck exercise with proprioceptive training was effective for pain relief.[25]

Saw Wah Wah et al.[24] stated that proprioceptive training group targeting the suboccipital muscles was effective than the craniocervical flexion training group and control group in improving static balance. The proprioceptors for preserving balance control are the spindles of the cervical muscles. Accurate kinaesthesia and proprioception are caused by the suboccipital muscle being strengthened during proprioceptive training.[24]

Strengths and Limitations

A controlled comparison design, the use of established outcome measures (VAS and JPET), and well-defined selection criteria that result in a homogeneous sample are among its main advantages. The relatively short intervention duration and lack of long-term follow-up limit assessments of durability; potential confounders, such as participants' screen time, postural habits, or daily activity, were not controlled, which may have an impact on results; and a modest sample size (n=30) limits statistical power and generalisability.

On comparing the data analysis between Group A and Group B, both the group shows significance differences between pre test and post test. But Group A shows high significance difference than Group B. Hence Virtual Reality Game Based Exercise was more effective than Proprioceptive Training on treating neck pain and neck proprioception among patients with forward head posture.

The results highlight the possibility of virtual reality game-based exercise as a useful supplement to physiotherapy regimens for pain and proprioceptive deficits associated with forward head posture, especially in younger, tech-savvy populations. Larger sample sizes, longer intervention durations, and follow-up evaluations to gauge the durability of benefits should all be part of future research. Furthermore, investigating VR and conventional proprioceptive methods together may help develop better hybrid therapeutic models.

CONCLUSION

The study concludes that the both virtual reality training and proprioceptive training was effective in improving the neck proprioception and reducing the neck pain among students with forward head posture. Proprioceptive training was like conventional method and less enthusiastic compared to Virtual Reality Training. Whereas Virtual Reality Training was more fun filled and students were more enthusiastic in playing through VR games. Thus Virtual Reality Training was better than Proprioceptive Training in improving neck proprioception and reducing pain.

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Conflict of Interest

The author(s) do not have any conflict of interest.

Data Availability Statement

This statement does not apply to this article.

Ethics Statement

The methodology employs a experimental comparative study and was carried out with the approval by the ethics committee of institution's review board, Faculty of Physiotherapy, Dr.MGR Educational and Research Institute with the letter numbered IRB REF NO: MPT /PHYSIO/ IRB/2024.

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Clinical Trial Registration

This research does not involve any clinical trials

Permission to reproduce material from other sources

Not Applicable

Author contributions

Conceptualisation: Vaishnavi Giridharan; Methodology: M.Majitha Parveen; Validation: Kamatchi Kaviraja; Formal analysis: Eliza giftson Titus Elumalai; Investigation: Elakkiya Rajaram; Data curation: Kamatchi Kaviraja; Writing - original draft: Ijaj Rahman; Writing - review and editing: Elavarasan kumar; Supervision: Vaishnavi Giridharan

REFERENCES

1. Mahmoud NF, Hassan KA, Abdelmajeed SF, Moustafa IM, Silva AG. The relationship between forward head posture and neck pain: a systematic review and meta-analysis. *Curr Rev Musculoskelet Med*. 2019;12:562–577.
2. Ghamkhar L, Kahlaee AH. Is forward head posture relevant to cervical muscles performance and neck pain? A case-control study. *Braz J Phys Ther*. 2019;23(4):346–354.
3. Kocur P, Lochynski D. Influence of forward head posture on myotonometric measurements of superficial neck muscle tone, elasticity and stiffness in asymptomatic individuals with sedentary jobs. *J Manipulative Physiol Ther*. 2019;42(3):195–202.
4. Kang JI, Choi HH, Jeong DK, Choi H, Moon YJ,

Park JS. Effect of scapular stabilization exercise on neck alignment and muscle activity in patients with forward head posture. *J Phys Ther Sci*. 2018;30:804–808.
5. Kim DH, Kim CJ, Son SM. Neck pain in adults with forward head posture: effects of craniovertebral angle and cervical range of motion. *Osong Public Health Res Perspect*. 2018;9(6):309–313.
6. Lee MY, Lee HY, Yong MS. Characteristics of cervical position sense in subjects with forward head posture. *J Phys Ther Sci*. 2014;26:1741–1743.
7. Ha SY, Sung YH. A temporary forward head posture decreases function of cervical proprioception. *J Exerc Rehabil*. 2020;16(2):168–174.
8. Alshahrani A, Aly SM, Abdrabo MS, Asiri FY. Impact of smartphone usage on cervical proprioception and balance in healthy adults. *Biomed Res*. 2018;29(12):2547–2552.
9. Choi J. Effect of kinesiology taping and posture stabilizing exercise on pain, craniovertebral angle, proprioception in adults with forward head posture. *J Int Acad Phys Ther Res*. 2019;10(3):1862–1867.
10. Raoofi Z, Sarrafzadeh J, Emrani A, Ghorbanpour A. Interaction between proprioception, forward head posture and neck pain in adult women. *Func Disabil J*. 2019;2:12.
11. Kataria J, Sindhu B, Pawaria S. Effect of mechanical neck pain with forward head posture on scapula position in primary school teachers. *J Med Sci*. 2020;13(1):25–30.
12. Behera P, Majumdar A, Revadi G, Santoshi JA, Nagar V, Mishra N. Neck pain among undergraduate medical students in a premier institute of central India: a cross-sectional study of prevalence and associated factors. *J Family Med Prim Care*. 2020;9:3574–3581.
13. Nejati P, Lotfian S, Moezy A, Nejati M. The study of correlation between forward head posture and neck pain in Iranian office workers. *Int J Occup Med Environ Health*. 2015;28(2):295–303.
14. Ali AA, Haq N, Hussain A, Rafique M, et al. Assessment of neck pain causes and its intensity among the students of Department of Eastern Medicine, University of Balochistan, Quetta, Pakistan. *Indian J Physiother Occup Ther*. 2021;15(2):139–144.
15. Saroha S, Preeti. To compare the effect of eccentric exercise vs concentric exercise when combined with wobble board exercise on proprioception of knee joint after inducing fatigue in quadriceps muscle. *Indian J Physiother Occup Ther*. 2021;15(2):147–151.
16. Goodarzi F, Jaberzadeh S. The effects of forward head posture on neck extensor muscle thickness: an ultrasonographic study. *J Manipulative Physiol Ther*. 2018;41(1):34–41.
17. Rahnama L, Abdollahi I, Karimi N, Akhavan N, Arab-khazaeli Z, Bagherzadeh M. Cervical position sense in forward head posture versus chronic neck pain: a comparative study. *J Clin Physio Res*. 2016;1(2):86–89.
18. Nusser M, Kramer M, Knapp S, Krischak G. Effects of virtual reality-based neck-specific sensorimotor training in patients with chronic neck pain: a randomized controlled pilot trial. *J Rehabil Med*. 2021;53:jrm00151.
19. Mukherjee M, Bedekar N, Sancheti PK, Shyam A. Immediate and short-term effect of virtual reality training on pain, range of motion, and kinesiophobia in patients with cervical spondylosis. *Indian J Phys Ther Res*. 2020;2:55–60.
20. Son HH. The effects of virtual reality games in posture correction exercise on the posture and balance of patients with forward head posture. *J Korean Soc Phys Med*. 2020;15(2):11–21.
21. Morales Tejera D, Beltran-Alacreu H, Cano-de-la-Cuerda R, et al. Effects of virtual reality versus exercise on pain, functional, somatosensory and psychosocial outcomes in patients with non-specific chronic neck pain: a randomized clinical trial. *Int J Environ Res Public Health*. 2020;17:5950.
22. Gumaa M, Khaireldin A, Youssef AR. Validity and reliability of interactive virtual reality in assessing the musculoskeletal system: a systematic review. *Curr Rev Musculoskelet Med*. 2021;14:130–144.
23. Rezaei I, Razeghi M, Ebrahimi S, Kayedi S, Rezaeian Zadeh A. A novel virtual reality technique (Cervigame®) compared to conventional proprioceptive training to treat neck pain: a randomized controlled trial. *J Biomed Phys Eng*. 2019;9(3):355–366.
24. Wah SW, Puntumetakul R, Boucaut R. Effects of proprioceptive and craniocervical flexor training on static balance in university student smartphone users with balance impairment: a randomized controlled trial. *J Pain Res*. 2021;14:1935–1947.
25. Yoo HJ, Choi JH. Effect of kinesio taping and proprioception training on pain, neck disability, craniovertebral angle, and muscle activity in forward head posture. *J Int Acad Phys Ther Res*. 2018;9(4):1619–1625.
26. Vaishnavi G, Mary SR, Kumari SSS, Priya RD, Menon AR, Clitty. Correlation of mobile phone addiction scale (MPAS) with the craniovertebral

angle and Beck's depression inventory in bike drivers and students. *Indian J Public Health Res Dev*. 2020;11(3):390–395.

27. Worlikar AN, Shah MR. Incidence of forward head posture and associated problems in desktop users. *Int J Health Sci Res*. 2019;9(2):97–101.
28. Dhinju BS, Paulraj M, Harithra S. Significance of cervical flexors strength training using EMG bio-feedback on forward head posture among college students. *Indian J Physiother Occup Ther*. 2021;15(2):172–176.
29. Quartey J, Ernst M, Bello A, et al. Comparative joint position error in patients with non-specific neck disorders and asymptomatic age-matched individuals. *S Afr J Physiother*. 2019;75(1):a1315.
30. Abdelkader NA, Mahmoud AY, Fayaz NA, Mahmoud LSE. Decreased neck proprioception and postural stability after induced cervical flexor muscles fatigue. *J Musculoskelet Neuronal Interact*. 2020;20(3):421–428.
31. Maxwell C. Sensitivity and accuracy of the visual analogue scale: a psycho-physical classroom experiment. *Br J Clin Pharmacol*. 1978;6:15–24.