ejpmr, 2021,8(12), 369-378

SJIF Impact Factor 6.222

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Research Article

ISSN 2394-3211

EJPMR

EFFECTIVENESS OF MOBILE BASED VIRTUAL REALITY TRAINING ON IMPROVING BALANCE IN ELDERLY POPULATION

Kancherlapalli Ooha Latha*[1], P. S. R. Thulasi[2], Patchava Apparao[3], Pappala Kiran Prakash[4], Ganapathi Swamy[5]

[1]Post Graduate Student,

[2]Assisstant Professor, Department of Physiotherapy, Swatantra Institute of Physiotherapy and Rehabilitation, GSL Medical College, Rajamahendravaram.

[3]Principle of College, Department of Physiotherapy, Swatantra Institute of Physiotherapy and Rehabilitation, GSL Medical College, Rajamahendravaram.

[4]Assisstant Professor, Department of Physiotherapy, Swatantra Institute of Physiotherapy and Rehabilitation, GSL Medical College, Rajamahendravaram.

[5]Asst. Prof. of Statistics, Department of Community Medicine, GSL Medical College, Rajamahendravaram.

***Corresponding Author: Kancherlapalli Ooha Latha**

Post Graduate Student.

Article Received on 04/10/2021 **Article Revised on 24/10/2021** **Article Accepted on 14/11/2021**

ABSTRACT

Background: Balance deficits due to physical deconditioning are the leading cause for falls in elderly, a major public health concern. Many evidence based studies proved Virtual Reality as one of the promising intervention to improve balance in elderly population by using costly setups like Nintendo Wii Fit Plus, Microsoft xbox360 sensor kinect video game consoles which were bit expensive to be available at all physiotherapy centers. Hence the need for low budget Smartphone Based Virtual Reality Balance Training is needed. **Methods:** Quasi Experimental study design. A total of 120 subjects, 103 met the inclusion criteria were randomly allocated into two groups. In Group-A (n=51) Mobile Based Virtual Reality Training and Conventional Balance Exercises were given, Group-B (n=52) Conventional Balance Exercises were given, 3 times a week for 5 weeks. The outcomes of this intervention were measured by BBS and TUG test. **Results:** Independent 't' test was used to differentiate the mean significance difference between continuous variables. Paired 't' was used to assess the statistical significant difference pre and post test scores. Within group comparison both groups showed significant improvement in all parameters where as in between group comparison Mobile Based Virtual Reality Training group showed better improvement. **Conclusion:** After 5 weeks of interventions, this study concludes that Mobile Based Virtual Reality Training is a useful adjunct on improving balance in elderly population along with conventional balance exercises.

KEYWORDS: Elderly, Mobile Based Virtual Reality Training, Conventional Balance Exercises, Berg Balance Scale, Timed Up and Go Test.

INTRODUCTION

Balance can be defined as controlling the body's centre of mass within the base of support during static and dynamic situations. It mainly relays on the coordinated and integrated actions of the sensory systems with the central nervous system. Afferent sensory information from visual, somatosensory, and vestibular systems should be integrated to analyse the complex sensory environments. All these systems interact in a closed loop to maintain balance. During the alterations in the sensory environment central nervous system changes the contribution of the senses to maintain postural balance. In normal environment with firm surface and good lightening the contribution of visual information for postural balance is 10%, vestibular information is 20%, and somatosensory information is 70%. With increasing age all these three systems undergo deterioration, Medication usage and age-related diseases also shows impact on this deterioration process leading to falls.[1]

Falls are the second leading cause of unintentional injury morbidity, 11% of unintentional mortality. World health organization (WHO) global report on falls prevention states that 65years and above aged people fall about 28%-35% every year, with increase in age and frailty level this fall proportion level also increases. In India the prevalence of falls ranges from 14%-53%, elderly females are more likely to experience balance problems than males (21.0% vs 17.7%).[2,3]

Falls in elderly people is mainly due to balance disorders which leads to significant health care burden, increased hospitalization, morbidity and mortality in elderly population.[4] Falls may result in loss of autonomy,

dependence, confusion, depression, and immobilization which comes under post fall syndrome.[5]

Above 65 years people were more susceptible for falls due to numerous factors, as the balance control system efficiency decreases substantially with age. Factors like age, sex, external (behavioural, environmental, and socioeconomic) and internal (health related) predispose to falls in elderly people. This risk factors along with involutional changes includes slowdown in nerve conduction velocity's which results in longer reaction time, motor coordination difficulty's, impaired visual acuity, peripheral vision abnormality, hearing impairment, impaired superficial and deep sensations, degenerative changes in ligament and tendons, abnormal gait patterns (short steps and increased double support phase) hair cells loss in vestibular sensors, decrease in the neuronal cell density in cerebral cortex, decreased vestibular neurons and purkinje's cells in cerebellum.[6,7]

The well designed exercise programs are evidenced to prevent the occurrence of falls and their related injuries in community dwelling elderly. Other fall preventive interventions were used by health care professionals by combining mixed approaches like strength training and balance exercises, which also includes the endurance exercise like walking.[8]

From the last three decades the technological advancement lead to the development and application of new innovative therapies for neurological recoveries, one of such advancement is ―"VIRTUAL REALITY". Virtual Reality classified basing on their level of immersion and the equipment's used, In Immersive VR we can visualize the computer generated environments with full field of view by head mounted displays (HMD-VR eg: Oculus Rift) or projection based systems, In semi immersive VR we visualize the computer generated environments with limited field of view(eg: monitor). Immersive VR mainly uses the immersive multimedia to stimulate the environment which may represents the real world or imaginary place. This immersive Virtual Environments which represents as real environment can be used in balance training in which the continues visual feedback is utilized as a sensory feedback for the vestibular system to perform successful activities. Along with this benefits the usage of VR avatars which displays on the screen performing the same balance activities provides a mirror feedback and helps to modulate their movements.[9,10]

VR has promising effect on improving balance in stroke,[11] parkinson's disease,[12] multiple sclerosis,[13] cerebral palsy(14) and cognitive decline.[15]

VRT received increased attention from researchers and clinicians because of its therapeutic potentials for falls prevention and balance rehabilitation.[16]

VR modernizes the clinical practices of rehabilitation. It uses game as resource to treat individuals with balance deficits with the use of electronic devices experienced by the human-machine interface. The patients were targeted to perform movements that stimulate brain activity, strengthen muscles, improves sensory response, increase balance, concentration, motor control and gait efficacy which encourages the neuroplastic changes to occur that reduces the fear of falling and helps to transfer to real world tasks through motor learning.[17,18]

Hsieh et al (2014) states that Virtual Reality Training shows 30% of reduced falls in elderly when compared to general exercise.[19] Miller et al(2014) states that VR balance exercises might be the better option for residents to motivate to start and continue the exercise program as they were more exciting when compared to Conventional Balance exercises.[20]

VR can be described in I^3 terms : Interaction + Immersion + Imagination.[21] Previously exergame systems use TV screens to project the game but new systems like portable head mounted displays having view of large fields(FOV) and stereoscopic visual fields which were updated using head position and rotation were used. This type of displays offer depth perception and blocks external visual information which offers acceptable, feasible and ecologically valid results.[22] The VR equipment specially designed for physical rehabilitation were not available in clinical settings, therefore game based motion controlled console, mobile devices, personal computers were used for VR rehabilitation programs, which were low cost and can utilize for variety's of gaming software's when needed.[23,24]

Many studies were conducted on the effect of Virtual Reality Training on balance, but very less work has been done on the Effectiveness of Mobile Based Virtual Reality Training on balance rehabilitation in elderly people. So the aim of the study is to know the Effectiveness of Mobile based Virtual Reality Training on Balance in elderly population.

MATERIALS AND METHODS

Study design: Quasi-Experimental Study Design.

Ethical clearance and informed consent: The study protocol was approved by the Ethical Committee of GSL Medical College & General Hospital (Annexure-I) the investigator explained the purpose of the study and given the subject information sheet. The participants were requested to provide their consent for participation in the study (Annexure-Ⅱ). All the participants signed the informed consent and the rights of the included participants have been secured.

Study population: Elderly Subjects with fall risk.

Study setting: The study was conducted at Out Patient Department of Physiotherapy, GSL Medical College and

General Hospital, Rajahmahendravaram, Andhrapradesh, India.

Study duration: The study was conducted during the period between July 2020 and June 2021.

Sampling method: Systematic Random Sampling.

Sample size: A total of 120 subjects were screened in that 103 subjects were recruited to participate in the study. Recruited participants were explained the purpose and relevance of the study. The participants were included in the study after obtaining informed consent. All eligible participants were randomized in to Mobile Based Virtual Reality Training group and Conventional Balance Training group.

GROUP	No. Of Subjects	TREATMENT
GROUP A	51	MOBILE BASED VIRTUAL REALITY TRAINING + CONVENTIONAL BALANCE TRAINING
GROUP B	52	CONVENTIONAL BALANCE TRAINING

MATERIALS USED: Head mounted VR gear
Android mobile phone
Stop watch
Tape
Chair

Fig. 1: Head mounted VR gear.

RESULTS

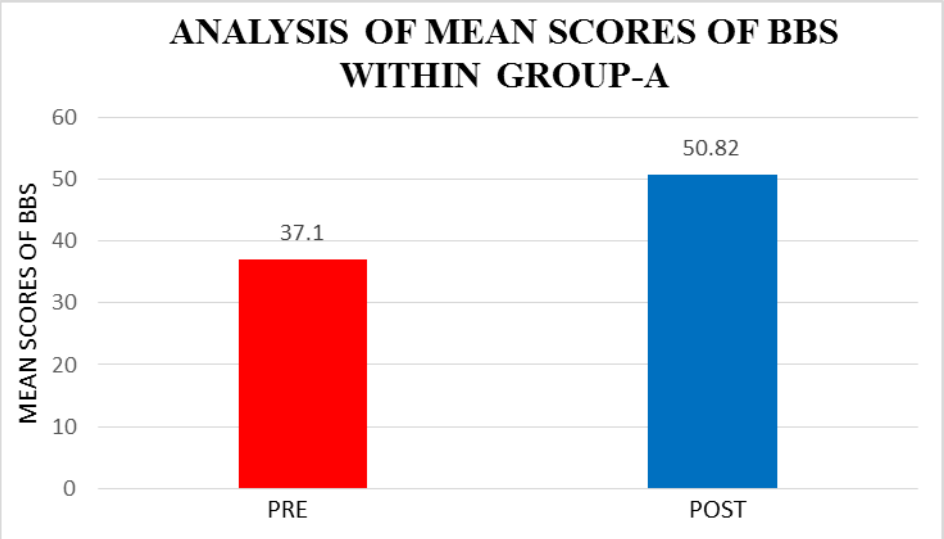
The aim of the study was to find the effectiveness of Mobile Based Virtual Reality Training on Improving Balance in Elderly Population.

A total 120 subjects were screened for eligibility, among them103 subjects were included in the study trail. All the 103 subjects undergone baseline assessment and subjects who met the inclusion criteria were randomized into two groups consisting 51 and 52 subjects.

In this study, 50 subjects completed training in Group-A and 50 subjects completed training in Group-B with dropouts of 1 and 2 in respective groups, results showed that there is a statistical difference in two groups.

Table 1: Analysis of Mean scores of BBS within the Group-A.

BBS	MEAN	SD	P-VALE	INFERENCE
PRE	37.10	1.799	0.000*	HIGHLY SIGNIFICANT
POST	50.82	1.224		

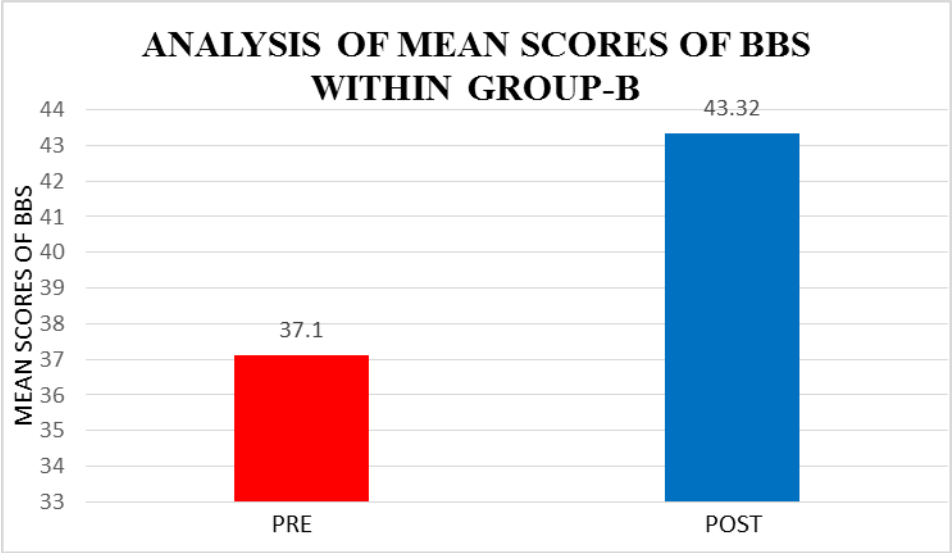


Graph 1:

Results: *The above Table and Graph shows that mean score of BBS changes from pre test to post test values within Group-A were found to be statistically significant (P<0.0)*

Table-2: Analysis of Mean scores of BBS within the Group-B.

BBS	MEAN	SD	P-VALE	INFERENCE
PRE	37.12	1.803	0.000*	HIGHLY SIGNIFICANT
POST	41.32	1.900		

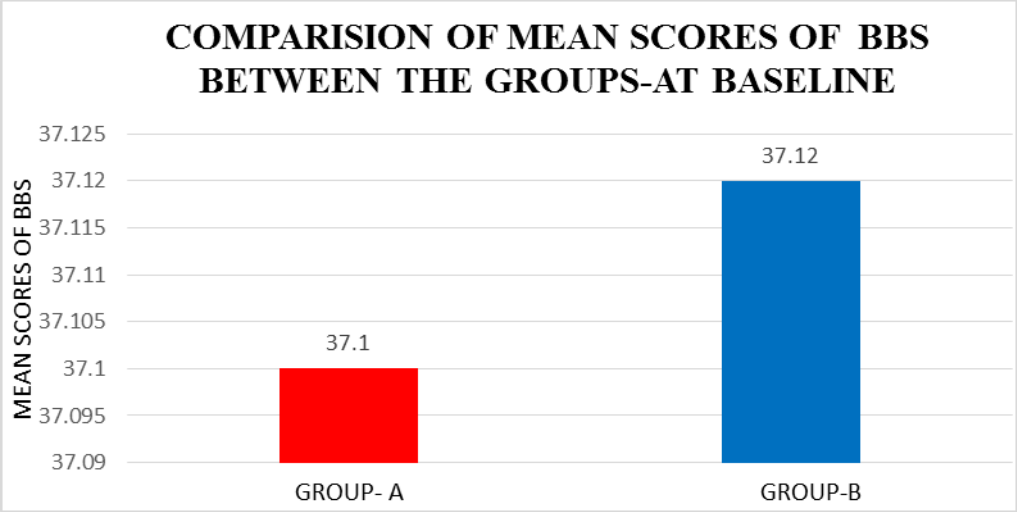


Graph-2:

Results: *The above Table and Graph shows that mean score of BBS changes from pre test to post test values within Group-B were found to be statistically significant (P<0.05).*

Table-3: Comparison of Mean scores of BBS between the Groups-A&B (Pre Test).

		Mean	SD	P-Value	Inference
PRE	Group A	37.10	1.799	0.917	INSIGNIFICANT
	Group B	37.12	1.803		

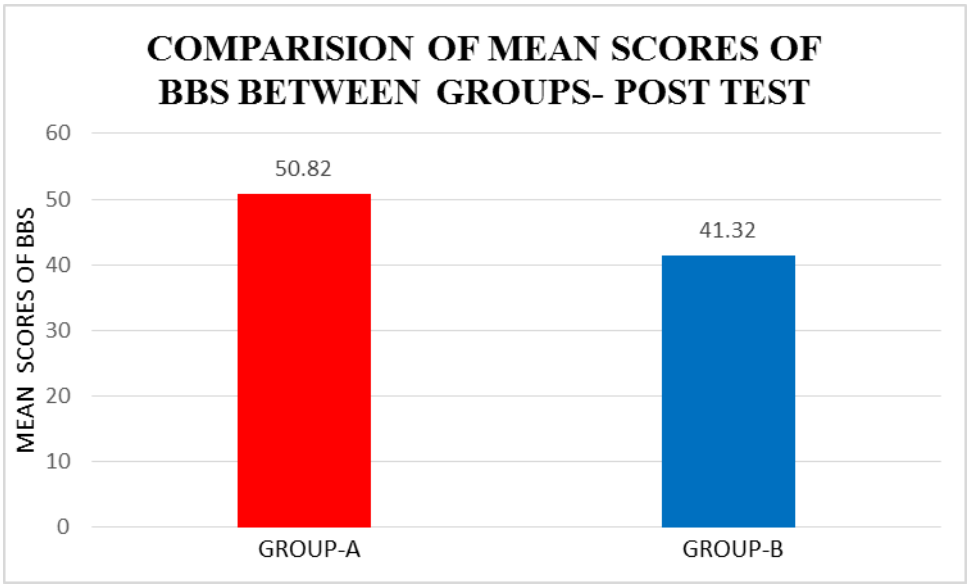


Graph-3:

Results: *The above Table and Graph shows the baseline measurement of BBS in Group-A (37.10) and Group-B (37.12) were found to be statistically Insignificant.*

Table-4: Comparison of Mean scores ofBBS between the Groups-A&B (Post Test),

		Mean	SD	P-Value	Inference
POST	Group A	50.82	1.224	0.000*	HIGHLY SIGNIFICANT
	Group B	41.32	1.900		

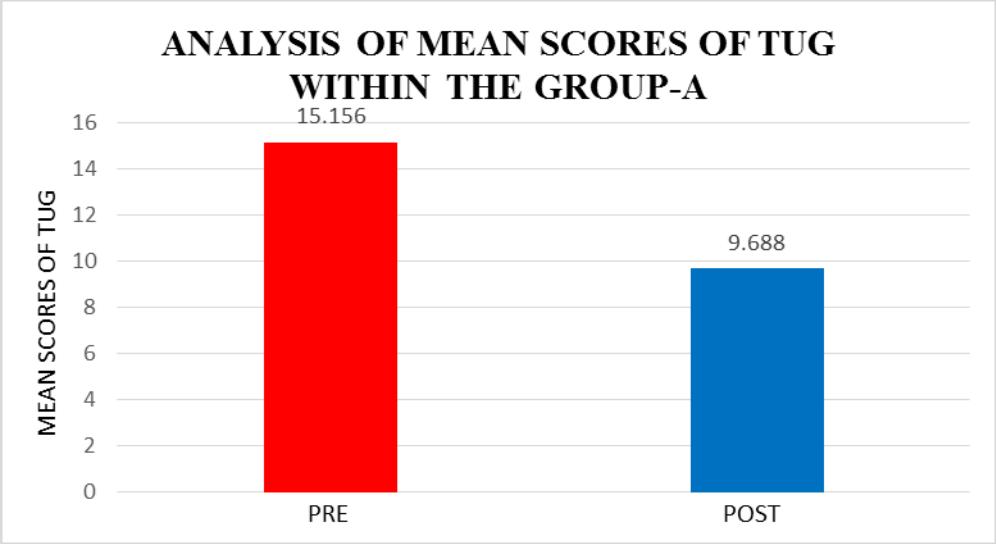


Graph-4:

Results: *The above Table and Graph shows the post test measurement of mean score of BBS changes between the Group-A (50.82) and Group-B (41.32) were found to be statistically significant (P<0.05).*

Table-5: Analysis of Mean scores of TUG within the Group-A.

TUG	MEAN	SD	P-VALE	INFERENCE
PRE	15.156	1.2443	0.000*	HIGHLY SIGNIFICANT
POST	9.688	0.7289		

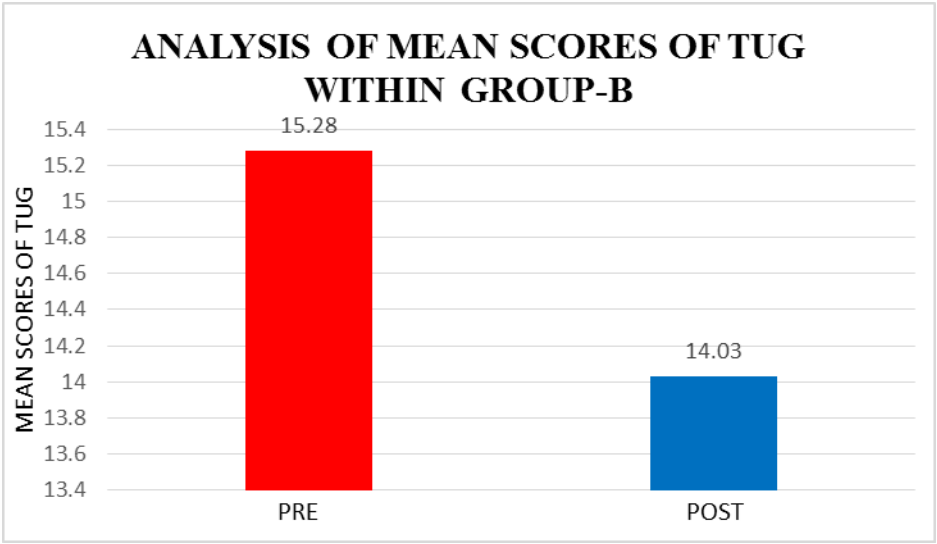


Graph-5:

Results: *The above Table and Graph shows TUG values changes from pre test to post test within Group- A were found to be statistically significant (p<0.05).*

Table-6: Analysis of Mean scores of TUG within the Group-B.

BERG	MEAN	SD	P-VALE	INFERENCE
PRE	15.280	1.3059	0.000*	HIGHLY SIGNIFICANT
POST	14.03	1.342		

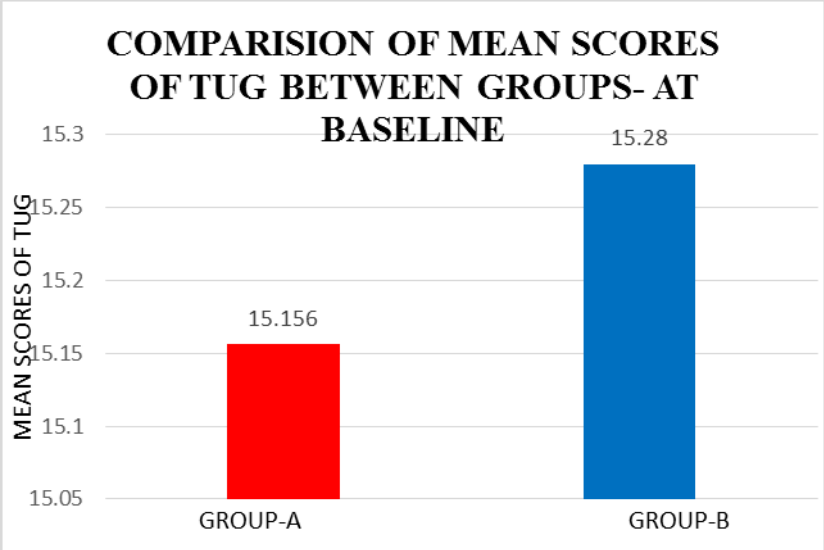


Graph-6:

Results: *The above Table and Graph shows TUG values changes from pre test to post test within Group- B were found to be statistically significant (p<0.05).*

Table-7: Comparison of Mean scores of TUG between the Groups-A&B (Pre -test).

		Mean	SD	P-Value	Inference
PRE	Group A	15.156	1.2443	0.885	INSIGNIFICANT
	Group B	15.280	1.3059		

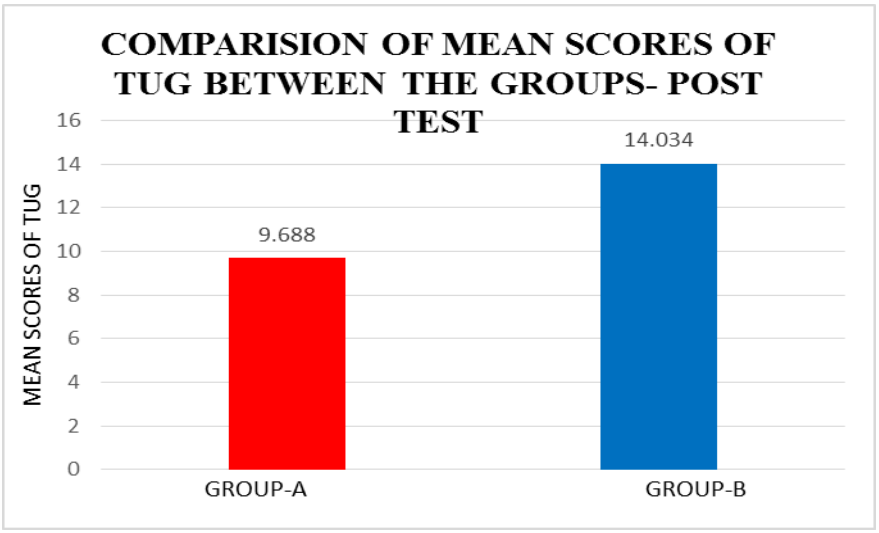


Graph-7:

Results: *The above Table and Graph shows the baseline measurement of TUG in Group-A (15.156) and Group-B (15.280) were found to be statistically insignificant.*

Table-8: Comparison of Mean scores of TUG between the Groups-A&B (Post-test).

		Mean	SD	P-Value	Inference
POST	Group A	9.688	0.7289	0.000*	HIGHLY SIGNIFICANT
	Group B	14.034	1.3423		



Graph-8:

Results: *The above Table and Graph shows the mean score of post test measurement of mean score of TUG changes between the Group-A (9.688) and Group-B (14.034) were found to be statistically significant (P<0.05).*

VR	Virtual Realty
VRT	Virtual RealityTherapy
BBS	Berg BalanceScale
TUG	Timed Up and Go test
HMD	Head Mounted Display

DISCUSSION

The present study is determined to investigate the "Effectiveness of Mobile Based Virtual Reality Training On Improving Balance in Elderly Population" a Quasi Experimental Study with 5 weeks protocol. Recently VRT has been used in rehabilitating stroke survivors, parkin-sons and cerebral palsy patients. Several studies have reported promising effects of VRT using Nintendo Wiifit, PlayStation, X box Kinect on improving balance, but there were limited studies on exploring the effect of Mobile Based Virtual Reality Training for balance improvement in elderly population.The main objective of

the study is low cost, easy implementation of treatment program by using mobile devices because of its small size and light weight they were portable without any problems regarding the persons surroundings. The treatment was administrated in therapy room to ensure safety of the subjects.

Group-A shows statistically more significant improvement in BBS (P<0.0001) and TUG (P<0.0001). Therapeutic effect of balance training using VRT is greater than that of Conventional Balance Training is mainly due to gaming effect such as immediate feedback from their movements, high attention, motivation and repeated activities which facilitates motor learning. Visual and auditory feedback while playing increases the subjects desire to interact. All this factors contribute to increased adherence to VRT. VR-Based intervention is more mentally and physically challenging compared to normal rehabilitation exercises because of its demand on cognitive organization and execution of synchronized motions. Virtual Games activate neural structures and circuits that transfers immediate game effect to long term effects.

Virtual Reality has evolved with a special importance for visual displays, Visual inputs has a dominant role in controlling balance of the human body. Moreover other afferents cannot be overlooked which includes vestibular system that senses head movements. Visual stimuli along with head movements are hypothesized to be used in training for balance control.[25] Cohen et al. showed that purposeful head movement exercises improved balance in vestibular patients.[26]

Steven M Peterson et al in his study states that VRT provides visual perturbations that induces different postural responses, which elicits the cortical response by increasing theta spectral power and decreasing alpha spectral power in parietal and occipital regions and that may have improved the brain's ability to adapt to variations in sensory input.[27]

Pooya Soltani and Renato Andrade et al in their study states that HMD VR can be used to train and assess the functional balance by offering ecologically valid scenarios and these HMD VR can also be used alone or with other treatments.[28] In our present study we used HMD VR with smart phone enclosed in it. The game "IN CELL VR"[29] used in our study is not specifically designed for balance training but the game program mainly targets the head movements which has greater impact on balance training by re-weightening of the sensor inputs, in this game the difficulty levels increases with speed. Specific tasks like hitting the proteins and avoiding the viruses makes it more interesting than continuous repetition of the constant movements.

As VRT is a playful intervention it encourages the participant to involve in balance rehabilitation. Thunyanoot Prasertsaku et al in his study states that VR based training alters the neural organization, encourages the neuroplastic changes in neurological patients, transferring to real world by motor learning and reduces fear of falling.[30] The study findings indicating that after 5 weeks of interventions VRT along with Conventional Balance Exercises were more effective than Conventional Balance Exercises alone in improving balance in elderly population. Thus this study concludes that Mobile Based Virtual Reality Balance Training is a useful adjunct in improving balance in elderly subjects.

This study can be helpful in increasing the awareness for physiotherapists to broaden their scope of rehabilitative care in elderly population without using highly advanced equipment's and costly setups. This program can also be used as home intervention under supervision.

CONCLUSION

The present study concludes that after five weeks of Interventions both groups were shown statistically significant improvement in post test values. However Mobile Based Virtual Reality Training along with Conventional Balance Training is more effective when compared to the Conventional Balance Training alone. Thus this study concludes that Mobile Based Virtual Reality Training has additional effect on balance and can be used as an adjunct to improve balance in elderly population.

ACKNOWLEDGEMENT

It is with a sense of pride and pleasure when I look back to acknowledge those who have been a source of encouragement in my entire endeavor.

I am grateful to ***Dr.GanniBhaskarRao, Chief Patron****, G.S.L Educational Institutions, Rajahmahendravaram, for his valuable support and help in permitting me to take the subjects from G.S.LMedical College& General Hospital.*

I take this pleasant and unique opportunity to express my deep sense of gratitude and offer my most sincere and humble thanks to my teacher ***My Principal Dr.Patchava Apparao****, MPT (orthopaedics) Ph.D.,MBA, and esteemed research* ***Guide Dr.P.R.S.Tulasi MPT (Neuro)****Assistant professor who helped me to shape my dissertation well right from the beginning and for allowing and supporting me to undertake the study and for the expert guidance, affectionate nature and friendly attitude.*

I also sincerely thank ***Dr.P.Chaturvedi*** *MPT Sports, Vice Principal& co guide* ***Dr. P.Kiran Prakash (****MPT) Neurology, Swatantra Institute of Physiotherapy and Rehabilitation, Rajahmundry for their valuable suggestions and constant look to bring out this work; for supporting me to complete the study. I whole heartedly thank to all my staff Members,* ***Dr.R.GeethaMounika,*** *and* ***Dr.P.Pundarikaksha****,* ***Dr.S.Jyothi, Dr.B.Meghana*** *for helping me to execute the dissertation.*

*I am immensely thankful to **DR. Ch. Ganapati Swamy**, Statistician, G.S.L Medical College, Rajamahendravaram, who helped me with his valuable and expert suggestions during the task of statistical analysis. I also thank my Librarian **Mr. B. Ramesh Babu** for his support.*

*I express my gratitude to **my friends** who helped me at every stage of my dissertation. I express my special thanks to all my subjects who were very cooperative during the course of dissertation. Last but not the least, I express my everlasting gratitude to **my Parents** for encouraging me and leading me through this gratifying task.*

KANCHERLAPALLI OOHA LATHA

REFERENCES

1. Pereira NM, Scheicher ME. Postural imbalance in the elderly: Main aspects. InGeriatric Medicine and Gerontology 2018 Nov 7. IntechOpen.
2. Pitchai P, Dedhia HB, Bhandari N, Krishnan D, D'Souza NR, Bellara JM. Prevalence, risk factors, circumstances for falls and level of functional independence among geriatric population-A descriptive study. Indian journal of public health, 2019 Jan 1; 63(1): 21.
3. Lin HW, Bhattacharyya N. Balance disorders in the elderly: epidemiology and functional impact. The Laryngoscope, 2012 Aug; 122(8): 1858-61.
4. Değer TB, Saraç ZF, Savaş ES, Akçiçek SF. The relationship of balance disorders with falling, the effect of health problems, and social life on postural balance in the elderly living in a district in Turkey. Geriatrics, 2019 Jun; 4(2): 37.
5. World Health Organization, World Health Organization. Ageing, Life Course Unit. WHO global report on falls prevention in older age. World Health Organization, 2008.
6. Kamińska MS, Miller A, Rotter I, Szylińska A, Grochans E. The effectiveness of virtual reality training in reducing the risk of falls among elderly people. Clinical interventions in aging, 2018; 13: 2329.
7. Hobeika CP. Equilibrium and balance in the elderly. Ear, nose & throat journal, 1999 Aug; 78(8): 558-66.
8. Hafström A, Malmström EM, Terdèn J, Fransson PA, Magnusson M. Improved balance confidence and stability for elderly after 6 weeks of a multimodal self-administered balance-enhancing exercise program: a randomized single arm crossover study. Gerontology and geriatric medicine, 2016 Apr 22; 2: 2333721416644149.
9. Iruthayarajah J, McIntyre A, Cotoi A, Macaluso S, Teasell R. The use of virtual reality for balance among individuals with chronic stroke: a systematic review and meta-analysis. Topics in stroke rehabilitation, 2017 Jan 2; 24(1): 68-79.
10. Huygelier H, Schraepen B, Van Ee R, Abeele VV, Gillebert CR. Acceptance of immersive head-mounted virtual reality in older adults. Scientific reports, 2019 Mar 14; 9(1): 1-2.
11. Li Z, Han XG, Sheng J, Ma SJ. Virtual reality for improving balance in patients after stroke: a systematic review and meta-analysis. Clinical rehabilitation, 2016 May; 30(5): 432-40.
12. Lee NY, Lee DK, Song HS. Effect of virtual reality dance exercise on the balance, activities of daily living, and depressive disorder status of Parkinson's disease patients. Journal of physical therapy science, 2015; 27(1): 145-7.
13. Ortiz Gutierrez R, Galan del Rio F, Cano de la Cuerda R, Alguacil-Diego IM, Arroyo González R, Miangolarra Page JC. A telerehabilitation program by virtual reality-video games improves balance and postural control in multiple sclerosis patients. NeuroRehabilitation, 2013 Jan 1; 33(4): 545-54.
14. Pereira EM, Rueda FM, Diego IA, De La Cuerda RC, De Mauro A, Page JM. Use of virtual reality systems as proprioception method in cerebral palsy: clinical practice guideline. Neurología (english edition), 2014 Nov 1; 29(9): 550-9.
15. Lee GH. Effects of virtual reality exercise program on balance, emotion and quality of life in patients with cognitive decline. The Journal of Korean Physical Therapy, 2016; 28(6): 355-63.
16. Rendon AA, Lohman EB, Thorpe D, Johnson EG, Medina E, Bradley B. The effect of virtual reality gaming on dynamic balance in older adults. Age and ageing, 2012 Jul 1; 41(4): 549-52.
17. Amorim JS, Leite RC, Brizola R, Yonamine CY. Virtual reality therapy for rehabilitation of balance in the elderly: a systematic review and META-analysis. Advances in rheumatology, 2019 Jul 29; 58.
18. Prasertsakul T, Kaimuk P, Chinjenpradit W, Limroongreungrat W, Charoensuk W. The effect of virtual reality-based balance training on motor learning and postural control in healthy adults: a randomized preliminary study. Biomedical engineering online, 2018 Dec; 17(1): 1-7.
19. Park J, Yim J. A new approach to improve cognition, muscle strength, and postural balance in community-dwelling elderly with a 3-D virtual reality kayak program. The Tohoku journal of experimental medicine, 2016; 238(1): 1-8.
20. Yeşilyaprak SS, Yıldırım MŞ, Tomruk M, Ertekin Ö, Algun ZC. Comparison of the effects of virtual reality-based balance exercises and conventional exercises on balance and fall risk in older adults living in nursing homes in Turkey. Physiotherapy theory and practice, 2016 Apr 2; 32(3): 191-201.
21. Burdea GC. Virtual rehabilitation–benefits and challenges. Methods of information in medicine, 2003; 42(05): 519-23.
22. Soltani P, Andrade R. The influence of virtual reality head-mounted displays on balance outcomes and training paradigms: A systematic review. Frontiers in sports and active living, 2020; 2: 233.

23. Kamińska MS, Miller A, Rotter I, Szylińska A, Grochans E. The effectiveness of virtual reality training in reducing the risk of falls among elderly people. Clinical interventions in aging, 2018; 13: 2329.
24. Lee MM, Lee KJ, Song CH. Game-based virtual reality canoe paddling training to improve postural balance and upper extremity function: A preliminary randomized controlled study of 30 patients with subacute stroke. Medical science monitor: international medical journal of experimental and clinical research, 2018; 24: 2590.
25. English GJ. Effects of vestibular rehabilitation on stepping stability (Doctoral dissertation, MGH Institute of Health Professions).
26. Cohen H, Kane-Wineland M, Miller LV, Hatfield CL. Occupation and visual/vestibular interaction in vestibular rehabilitation. Otolaryngology—Head and Neck Surgery, 1995 Apr; 112(4): 526-32.
27. Peterson SM, Rios E, Ferris DP. Transient visual perturbations boost short-term balance learning in virtual reality by modulating electrocortical activity. Journal of neurophysiology, 2018 Oct 1; 120(4): 1998-2010.
28. Soltani P, Andrade R. The influence of virtual reality head-mounted displays on balance outcomes and training paradigms: A systematic review. Frontiers in sports and active living, 2020; 2: 233.
29. Syed-Abdul S, Malwade S, Nursetyo AA, Sood M, Bhatia M, Barsasella D, Liu MF, Chang CC, Srinivasan K, Raja M, Li YC. Virtual reality among the elderly: a usefulness and acceptance study from Taiwan. BMC geriatrics, 2019 Dec; 19(1): 1-0.
30. Prasertsakul T, Kaimuk P, Chinjenpradit W, Limroongreungrat W, Charoensuk W. The effect of virtual reality-based balance training on motor learning and postural control in healthy adults: a randomized preliminary study. Biomedical engineering online, 2018 Dec; 17(1): 1-7.