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Effects of Virtual Reality Based Training (VRBT) and Proprioceptive Training for Improving Dynamic Balance in Chronic Ankle Instability (CAI) Patients - A Comparative Study

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ABSTRACT

Chronic ankle instability (CAI) is define as, the tendency toward repeated ankle sprain and improper treatment, recurring symptoms like pain, weakness, giving way feel. CAI classified into mechanical ankle instability and functional ankle instability. Balance is most commonly affected in CAI due to loss of proprioception. To find out the effectiveness of virtual reality based training (VRBT) and proprioception training in CAI for improving dynamic balance. 30 CAI subjects were selected by talar tilt and anterior drawer test and 15 consist in Group A-VRBT and 15 in Group B-proprioception training for 10 weeks. Pre -Post-test measure by star excursion balance test (SEBT) and foot and ankle disability index and Sport modules (FADI-S). Group A and Group B had improvement in dynamic balance and functional activity. Group A shows significant difference from group B in all outcome measures. The independence sample t-test in anterior p-value .000 less than .05, in P-L p-value .017 less than .05, in P-M p-value .038 is less than .05, and in FADI-S p-value .000 less than .05. Proprioception improved in both group as well as feedback, reaction time also increase in VRBT group. It was concluded that virtual reality based training is more effective than proprioception training for improving dynamic balance in chronic ankle instability.

Keywords: CAI, VRBT, Proprioception Training, Dynamic Balance, SEBT, FADI-S

INTRODUCTION

Bipedalism is the main form in human locomotion where a human move by means of legs with hand swing [1]. An ankle-foot complex is one of the most important region of a human body in bipedal locomotion and it is extremely complicated structure including bone, multi-articular muscle, tendons, and other soft tissues such as walking,



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running, jumping because it is unique one that physically interacts with the environment [2]. If any injury occurs in our lower extremities it effects our locomotion e.g. sprain, compartment syndrome, fracture, tendinopathy etc. During heel -strike to mid-stance phase of gait cycle more weight passes to ankle joint. So, that ankle injury is very common during this phase of gait cycle [3]. Ankle sprain is the common injury in lower extremities and mostly all person experiences it once in a life time even at activities of daily living, during sports, or deformities may also play a role in the predisposition to the lateral ankle sprain [4,5,]. The usual mechanism of lateral ligament injury is inversion and plantarflexion of foot while the body center of gravity rolls over the ankle.⁶ If the ankle ligament does not heal adequately or recurrent ankle sprain occur may develop instability due to loss of mechanoreceptors located in the joint [6,7]. The tendency toward repeated ankle sprain and improper treatment, recurring symptoms like pain, weakness, giving way feel has been termed as chronic ankle instability (CAI). The ankle will feel loose and unstable [8]. CAI classified into mechanical ankle instability(MAI) and functional ankle instability(FAI). MAI is characterized by pathological laxity of lateral ankle ligament. And FAI is characterized by impaired proprioception, neuromuscular control, postural control without ligamentous laxity [9]. When the ankle ligament is damage, there is loss of mechanoreceptor activity provide essential feedback to the brain and decreased muscle strength of invertor and evertor muscle [7]. This reduces the proprioception at the ankle joint and loss of balance [7,10]. Mechanoreceptors located in joint capsule, muscle tendon and skin. Studies have shown decreased proprioception abilities in patients with CAI [7].

The manifestation of functional instability include impairment in sensorimotor control, with has been previously quantified by the mean of static and dynamic balance task [4]. Talar tilt test and anterior drawer test are test for assessing the CAI [11]. CAI mostly seen in the individual with recurrent ankle sprain, and those does not take proper treatment. International figures report that ankle sprains with are basically weight-bearing injuries represent 15-20% of all sport injuries and remaining presentation to daily activities, accident [12]. An age of 10-19 years old is associated with higher rates of ankle sprain in male and female. Between 15-24year-old have higher rate of ankle sprain in male than female, whereas over thirty-year-old have higher rate in female than male [13]. Numerous treatment facilities available in CAI to improve balance. Proprioception is a neuromuscular process concerned with internal kinesthetic awareness of body position and movement [14,15]. Proprioception training challenges the ability of the targeted joint to detect and react to afferent input regarding joint position.

Virtual reality technology is developed on a computer hardware and software environment, to generate visual, audio and haptic feedback and obtain an interactive experience in the visual space, which strives to give users the impression of a real environment. It focuses on three characteristics-autonomy, interaction, and sense of being [16]. Star excursion balance test (SEBT) is a dynamic test to assess physical and functional performance of the lower extremities [17]. Foot and ankle disability index and sports modules (FADI-S) designed to evaluate the functional limitation in sports and activities of daily living related to foot and ankle conditions [18]. So, using SEBT and FADI-S can assess the patient's functional limitation and dynamic balance in CAI patients. If ankle get injured, proprioception affects and balance loss. So, it is necessary to retrain the dynamic balance and retain the normal ankle function. This study gives more emphasis for improving balance in CAI patients. My endeavor is to increase the dynamic balance and improve functional activities.

BACKGROUND FOR THE STUDY

The chronic ankle instability (CAI) occurs due to recurrent ankle sprain and without proper treatment. The CAI are very common in sports and also happen in activities of daily living at young age in both gender. Due to CAI, balance is also affect and its difficult in day to day life. For sports person due to CAI they will be unable to participated in the competitions.

In this study VRBT and proprioception training is use for CAI. Hence the need arises to evaluate which one is more estimate in chronic ankle instability.



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METHODOLOGY

In this study materials are used X-box one console with kinetic 360(Microsoft), CD (Kinect adventures, your shape fitness evolved) exercise mat, ball, wobble board, minitrampoline, elastic strap, SEBT measurement tool (inch tape), FADI-S Scale and assessment form. This was an experimental study. The subjects from the city of Calicut, Kerala. Subjects diagnosed with chronic ankle instability by doing talar tilt test and anterior drawer test. 30 subjects were selected by convenient sampling technique. Study duration 1 year, Treatment duration 10 weeks. Inclusion criteria are age 14-30 years, both genders, diagnosed grade I and II ankle sprain, history of ankle sprain past 6 months to 1 year. Any injury or surgery done in ankle joint, deformity at lower extremity, other musculoskeletal condition like fracture, osteoporosis, neurological condition like parkinsonism disease, ataxia, stroke, muscular dystrophy, myasthenia gravis, cardiopulmonary conditions- [American Heart Association Classification Class C and D], according to Manual Muscle Test < 4/5 grade, color blindness, pregnancy, tumors in the area to be treated for the study were excluded. Star excursion balance test (SEBT) and Foot and Ankle disability index and sports modules (FADI-S) were used to measure dynamic balance in CAI patients. 30 subjects were assessed and who fulfilled the inclusion and exclusion criteria were selected from the population. And divided into 2 groups, each group contains 15 subjects. Pretest value of SEBT and FADI-S of Group A and Group B were taken and compared each other. Group A were given VRBT and Group B were given proprioception training. Before treatment pre-test value and after 10-week training post-test value were taken.

PROCEDURE

SEBT has eight directions based on protocol three directions anterior, anteromedial and anterolateral directions were measured and also challenge to subject in balance, postural control, strength, range of motion and proprioceptive abilities. Tap is placed into three directions as Y shaped. Each line is separated by a 45-degree angle. While maintaining balance, person stands on one leg in center and using other leg to reach as far as possible in three directions. FADI-S is a questionnaire scale contains 136 total score given to the individuals for grade the score. Some individual if complaining pain after treatment ice pack is given for 15 minutes.

Group A- Virtual Reality Based Training

Training periods: 2 times per week, 24 min per session, 2 repetitions of 3 min, 60s break of each repetitions

Games: Rally Ball, Reflex Ridge, River Rush, Light Race

Week 1-4 in basic free play mode (9 levels). Week 5-7 in intermediate free play mode (9 levels). Week 8-10 in advanced free play mode (9 levels). 2 repeats of 3 min Break 60s between repetitions for all games. The participant's movements were monitored by a motion detecting camera as they played XBOX games. Participants had the opportunity to choose the order in which they would play the balance games, without allowing them to change their time engagement.

Group B - Proprioception Training

Training period: 2 times per week, and 24 min per session consisted of six stations, 2 repetitions of 45s, 60s break to next repetitions.

Exercise 1: Maintain the balance on single leg stance on exercise mat with the contralateral leg flexed. lower and raise the body. Distributed load on the foot.

Exercise 2: Jump from one leg to the other on an exercise mat and control landing for 4 seconds. Raise the contralateral leg.

Exercise 3: Maintain balance while walking on inclined surface

Exercise 4: Maintain balance in single-leg stance on wobble board. The contralateral leg is rested on an inclined surface nearly without being loaded.

Exercise 5: In mini trampoline patients have to jump and maintain the balance while landing down.

Exercise 6: Maintain balance in single-leg stance elevating the contralateral leg against resistance of an elastic strap.



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The games and exercises varied each week starting with the easiest level and ending with the most difficult level.

TECHNIQUES OF DATA ANALYSIS AND INTERPRETATION

SPSS20.0 software was used. Kolmogorov-Smirnov test was done to find out the normality. Paired t test was used as parametric test to find out the intra group significance. Independent t-test were used to analyze inter-group significance. Mann Whitney test were used to analyze inter-group significance.

RESULT

Group A And Group B

Evaluation of SEBT (ANTRIOR), (POSTERIO LATERAL), (POSTERIO MEDIAL)

By comparing the mean value of pre test and post test values of SEBT 3 set, post value which is greater than the pre test value, (Table 1) which indicates that there is an increase in balance. Also by analyzing the pre test and post test values by paired t-test, the p-value is less than .05, (Table 1) which indicates that there is significant difference between pre test and post test values.

Evaluation of FADI-S

By comparing the mean value of pre test and post test values of FADI-S, post test value which is greater than the pre test value (Table 1) which indicates that there is an increase in function. Also by analysing the pre test and post test values by paired t-test, the p-value is less than .05, (Table 1) which indicates that there is significant difference between pre test and post test values of FADI-S.

When comparing the post test values of SEBT ANTERIOR, SEBT POSTERO LATERAL, SEBT POSTERO MEDIAL and FADI-S of both group A and group B (Figure 1) through analysis of inter group significance; using independent sample t-test: SEBT ANTERIOR have the p-value .000 ($\alpha = .05$) (Table 2), SEBT POSTERO LATERAL have the p-value .017 ($\alpha = .05$) (Table 2), SEBT POSTERO MEDIAL have the p-value .038 ($\alpha = .05$) (Table 2) and by using Mann Whitney test FADI-S have the p-value .000 ($\alpha = .05$) (Table 2). This shows that group A shows significant difference from group B in all outcome measures. Hence, we can reject null hypothesis & accept the alternate hypothesis that, "there is significant difference in effectiveness of Virtual Reality Based Training (VRBT) and Proprioceptive Training For Improving Dynamic Balance In Chronic Ankle Instability (CAI) Patients".

DISCUSSION

This study is to find out the effectiveness of virtual reality based training (VRBT) and proprioception training for improving balance in chronic ankle instability (CAI) patients. In 2014, Nikalos V has evaluated the effect of X-box Kinect intervention on balance ability for previously injured young competitive male athletes by using overall stability index and limits of stability. He concluded that XBK is improve balance ability in injured ankle [16]. Cailbhe Doherty has evaluated a study dynamic balance deficit in individuals with chronic ankle instability compared to ankle sprain copers one year after a first-time lateral ankle sprain injury. Has founded that individual with CAI have problem with balance, that ankle joint motions is reduced capacity of the stance limb [19]. Proprioception training affect the mobility and balance function by altering proprioceptive receptors input information and improves the control of musculoskeletal motor system and balance function [20,21,22]. Proprioception consist of both sensory and motor nerve that send and receive impulses to and from central nervous system from stimuli with in the muscle spindle, Golgi tendon [23]. These impulses transmit vital information in a given muscle and the relative position of a body part during a given movement [24,25].

In virtual reality main principal is neuroplasticity, mirror neuron, reaction time, and feedback. Virtual reality stabilizes and accurately control the movements which improve functional ability and balance [26,27]. Previous





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studies also reported that motivation and active participation produces better functional results [28]. Gyeong H C [29] and Fathy A E [30] has done a study on VR training is effective for improving balance and also reduce risk of fall. Evidence suggest that individuals with CAI will have difficulty in balance. Using proprioception training for increasing balance recurrence of ankle sprain can be prevent. In this study, dynamic balance and functional activities is improvements in VRBT when compared to proprioception training. According using of outcome measure of SEBT and FADI-S. Therefore, the study is favoring the alternate hypothesis. Hence the study reveals that VRBT shows greater improvement than proprioception training on dynamic balance in CAI patients. Limitations of the study are sample size was small, Grade I and II CAI population is only taken, follow-up of VRBT and proprioception training was not done, dynamic balance and functional ability were only studies, the results in this study cannot be generalized to the whole ankle instability population, Lack of control group. Based on recommendations for future research the Comparison of VRBT and proprioception training can be done in a larger population, using another outcome measure for assessing dynamic balance, further studies can be done with either male or female only, Long term follows up study to analyses the long-lasting effect.

CONCLUSION

Both interventions showed good improvement in dynamic balance and functional activity over a period of ten weeks treatment. Based on outcome measure and statistical analysis virtual reality training has greater improvement in balance as compared to proprioception training. From this study, it concluded that virtual reality based training is effective for improving dynamic balance in chronic ankle instability as compared to proprioception training.

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Table 1: Intra Group Analysis of descriptive data for SEBT and FADI-S

Group	Measures	Test	Mean	Std. Deviation	Paired-t value	Degree of freedom	P value
Group A	SEBT (ANTERIOR)	PRE TEST	82.0867	10.86790	-18.126	14	0.000
		POST TEST	90.7267	10.01388			
	SEBT (POSTERO LATERAL)	PRE TEST	92.5600	10.70272	-10.087	14	0.000
		POST TEST	100.613	9.25881			
	SEBT	PRE TEST	89.9033	5.23486	-6.060	14	0.000





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	(POSTERO MEDIAL)	POST TEST	94.2400	6.71191			
	FADI-S	PRE TEST	89.2333	2.99492	-7983	14	0.000
		POST TEST	95.0367	.91153			
Group B	SEBT (ANTERIOR)	PRE TEST	82.6067	10.64555	-15.888	14	0.000
		POST TEST	88.5067	9.99046			
	SEBT (POSTERO LATERAL)	PRE TEST	92.5933	11.02377	-18.126	14	0.000
		POST TEST	98.4400	9.46164			
	SEBT (POSTERO MEDIAL)	PRE TEST	89.3073	5.16861	-3.763	14	0.002
		POST TEST	92.3867	6.42716			
	FADI-S	PRE TEST	87.1267	1.75600	-11.954	14	0.000
		POST TEST	89.5067	1.52525			

Table 2: Inter-Group Significance for SEBT and FADI-S

SL. NO	MEASUREMENT	TEST	STATISTICAL	P VALUE
			T/Z VALUE	
1	SEBT- ANTERIOR	INDEPENDENT SAMPLE T-TEST	-4.535	.000
2	SEBT(POSTERO LATERAL)	INDEPENDENT SAMPLE T-TEST	-2.541	.017
3	SEBT (POSTERO-MEDIAL)	INDEPENDENT SAMPLE T-TEST	-2.182	.038
4	FADI-S	MANN-WHITNEY TEST	-3.991	.000

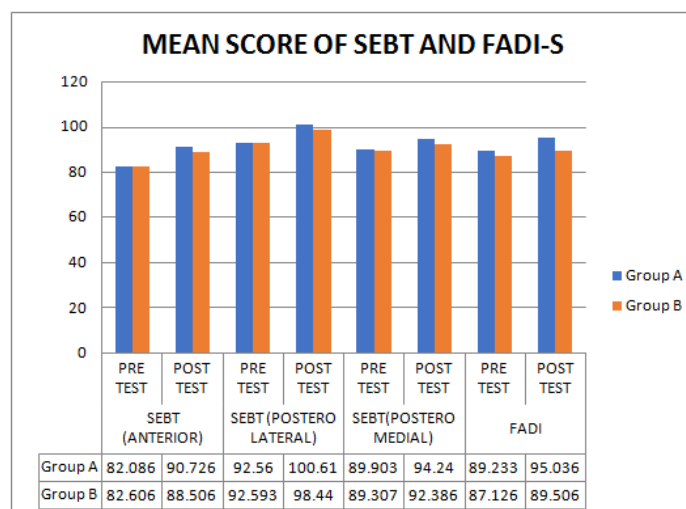


Figure 1: Mean score of SEBT and FADI-S

