Original Research Article

Comparison of Traditional Versus Virtual Reality Balance Training in Overweight Individuals

Izhar Ahmad[1], Piyush Singh[2]

[1]Student of Masters of Sports Physiotherapy, [2]Assisstent Professor,
Indian Spinal Injuries Center, Institute of Rehabilitation Sciences, Vasant kunj, New Delhi 110070

Corresponding Author: Piyush Singh

ABSTRACT

BACKGROUND - Balance is an important index in the evaluation of the overweight/ obese individual's activity. Previous studies performed in prepubertal obese individuals, confirmed increased postural instability, signified by increased stance phase time and lower walking speed. SEBT and UPST have been described as a test of dynamic postural control. Virtual reality and traditional programme has been used in sports and other abnormalities for balance training.
AIMS & OBJECTIVES - This study investigated effect of traditional and virtual reality balance programme, in overweight individuals, on static and dynamic balance.
METHEDOLOGY- 60 subject of age 18-36 years participated in the study, subjects were randomly allotted to three groups (n=20 each): Control, virtual reality and traditional. Pre-testing for static and dynamic balance was measured for all 3 groups using unipedal stance and Star excursion balance test respectively. Balance training for all the groups was performed for 20-30 min, thrice a week for 6 weeks. Post test readings were obtained after every 2 week and final reading was taken after 6 week of training.
RESULT- Analysis between the group using one way ANOVA, revealed that there was a significant difference in static balance in all the groups ($p<0.001$). Within group analysis was done using pair t-test. Mean values of pre and post intervention static and dynamic balance showed maximum improvement in traditional balance Group. However, there was no significant difference found in virtual reality group.
CONCLUSION- These results provide support for the use of traditional balance training in overweight individuals.

Keywords- Virtual reality, Traditional balance training, SEBT, UPST, overweight.

INTRODUCTION

According to WHO, (2000) Overweight and obesity in numerous developing nations, not give careful consideration and is focused on starvation and under sickness or unhealthiness of youngsters. In the event that preventive measures are not defined, in these regions the issue may raise and overburden the human services framework. Subsequently there is requirement to define measures in order to capture the issue of overweight and heftiness and keep the negative impact away in people, particularly among women.

Balance is characterized as the methodology that keeps up the core of gravity inside the body's support base and obliges consistent alterations that are given by strong action and joint situating. Most anxious and musculoskeletal framework maladies can change this balance control. [1]

Maintenance of postural balance requires sensorial location of the body's developments, coordination of kinesthesia data into the focal sensory system and a proper engine reaction. The position of the body part in connection to environment is dictated by physical sensitivity and visual, vestibular capacities. Strong control and element support of balance include the movement of directions of solid active chains. [2]

Adipose tissue aggregation and body mass increments can result in a decrease in the body adjust and be a real contributing variable in regards to falls, particularly when consolidated with low strong mass, which can produce biomechanical disappointment of solid reactions and loss of soundness mechanisms. [3]

The susceptibility of weight addition like overweight, and additionally create illnesses inconvenience relies on upon hereditary inclination. For example, the vitality utilization rate, capacity to store fat dispersion as fat tissue, and the association between large amounts of blood lipids and atherosclerosis indicate extensive bury singular variety. Physical latency is, not withstanding, a significant component for each person, and the ailment hazard inconvenience is decreased by expanded movement, incorporating in overweight individuals. [4]

Through and through; a few studies support the perspective that overweight can yield poorer balance. All the more as of late, it was accounted for that in obese teenagers comparable results discovered however just when the postural control was focused by including a froth surface. Including a froth surface probably give the lower appendages somatosensory information and obliges a more prominent dependence on the staying tangible frameworks. They said that the less stable carriage was the after effect of overweight without anyone else as well as could be identified with tactile combination problems. [3,5]

Muscle shortcoming and poor balance have been settled as danger components for falls in imminent associate studies in population. [6,7]

Postural control is any demonstration of keeping up, accomplishing or re-establishing harmony in any static or element body position. Balance characterize is the condition of balance whereby the net drive or aggregate of strengths, following up on the body is zero. By and by, this implies that so as to look after balance, postural control methodologies must be utilized to neutralize power that demonstration to move the body with balance. Development and offset deficiencies may be reflected in hindered capacity to stand, exchange movement, incline or achieve, and react to annoyance. The adequacy of these movements is measured through varieties in COP or body influence in static balance tests. Since the objective of postural control is to minimize changes in body influence by amending them rapidly, the size and pace of these movements gives an evidence of the viability of postural control instruments inside the body. [8]

Balance preparing

Balance preparing can be characterized as a preparation regimen that goes for an enhanced postural control. [9] Balance preparing has been utilized as a part of distinctive age and patient gatherings to upgrade different neuromuscular limits e.g., balance capacity, maximal and hazardous power generation etc and in studies going for fall anticipation. [10] At the point when

directing balance training, it is expected that the neuromuscular framework adjusts particularly and continuously to the connected preparing power. [10] It has as often as possible been demonstrated that a decreased base of support or denied visual control brings about a bigger postural influence. [11]

Improved balance preparing activities are intended to enhance certainty, portability, and working in a day-today connection. Balance preparing incorporates harmony control practices that are tedious and reviewed in many-sided quality that upgrade adjust by enhancing influence control and restraining unseemly motor responses. [12,13]

Multisensory offset programs

Programs which join multisensory preparing and particular balance exercises are more powerful for enhancing balance when contrasted with traditional activity programs that comprise just of high impact exercise, reinforcing, or adaptability exercises. [14]

A study said, a multisensory balance program, which obliged subjects to twist, turn, and achieve, while keeping up offset on different surfaces, was contrasted with a balance program different traditional preparing, which exists of regular offset exercises, for example, walking set up, tender stretching exercises, arm development and stepping to the side. It gave extra vestibular incitement and urged members to expand their rate and size of developments to look after balance, which brought about expanded continuance, quality, and response time in individuals. [14]

A traditional treatment program, which comprised of different motility aptitudes, was contrasted with a motivate balance program, which obliged members to keep up a tight base of support, while moving the inside of gravity outside of the base of support. The increase treatment program additionally comprised of reiteration of evaluated balance exercises and members got visual criticism from the Balance Performance observed which gave a target assess of balance by measuring a member's postural influence and all the offset. Both the tradition balance gathering and the upgraded treatment gathering demonstrated changes in balance, strolling velocity number of falls, personal satisfaction, freedom for exercises of day by day living, and social cooperation; however the improved treatment gathering indicated more enhancements in walking speed, soundness, and nature of life. [15]

Attractive games, for example, Dance Revolution and gaming natural frameworks, for example, Play Station 2 and Wii can be seen in non-intrusive treatment and games drug skill. The developing interest of Attractive gaming incompletely is because of the conviction that playing intuitive video game amid a rehabilitation session can coordinate an understanding's concentrate far from the monotonous and ordinary nature of recovery activities and toward the fun and focused parts of the video game. [16,17]

In this manner, intriguing gaming technology subjectively enhances adherence rates for restoration programs [18] and presents allied health services suppliers with an assistant to traditional rehabilitation works out.

Then again, Nintendo Recently discharged the Wii Balance Board (Nintendo of America Inc) as a controller for Games, for example, Wii Fit (Nintendo of America Inc) and Wii Fit Plus (Nintendo of America Inc). The Wii Balance Board have attributes like an research grade plate and contains transducers used to survey power distribution and the consequent developments of a singular's focal point of weight (COP). In this way, the Wii Balance Board joins current power stage innovation

with the diversion benefit of gaming while finishing exercises related wellness, yoga and balance. Besides, the Wii Fit and Wii Fit Plus amusements incorporate customized settings to track a individual's change over the time. The fulfillment of these exercises professedly pick up balance, and some health awareness suppliers have given that parts of attractive game, for example, offset scores and player rating, may be identified with sensorimotor function**. [19]**

Besides, uncertainty exists about the validity and reliability of the balance scores that emerge from the product actualized in the Wii Fit and Wii Fit Plus amusements. Until this data is advance, clinicians utilizing balance scores result from the Wii Fit or Wii Fit Plus diversions to screen advancement amid recovery may be settling on clinical choices inaccurate or not dependable information. Accordingly, the motivation behind this examination was to focus the simultaneous legitimacy and the intra session and intersession dependability of balance scores the Wii Fit diversion produces. **[20]**

AIM:-To determine the effect of balance between traditional and virtual reality balance training in overweight people.

OBJECTIVES
- ➤ To choose the suitable subjects for the training of effect of balance on traditional and virtual reality balance.
- ➤ To screen the test on the basis of effectiveness on the overweight subjects.
- ➤ To evaluate positive effect of test and validation of hypothesis by evaluating statistical significance between the control and test groups.

MATERIALS AND METHODS
Approval was obtained from the Research Review and Ethical committee of ISIC Institute of Rehabilitation Sciences. Written information consent was acquired from all subjects.

Participants:
Study Design: - Pre and post experimental

A Convenience sample of 60 overweight individuals of age 18-36 years [21] voluntarily participated in the study (descriptive information of the subjects given in Table 1). Subjects were screened as per the inclusion and exclusion criteria given below and randomly allotted to three group (n=20) each: Control, Virtual reality and Traditional Group.

INCLUSION CRITERIA
1. Age group between 18 to 36 years; (BMI: 25-29.9) [22]
2. Subjects unable to maintain the normal excursion distance on the supportted leg throughout the trail on SEBT**. [23]**
3. Subjects unable to maintain the balance (5< poor < 45sec) on unipedal stance test. [23]
4. Subjects with a functional range at shoulder, lumbar spine, hip, knee and ankle.

EXCLUSION CRITERIA [24]
1. Ankle instability in past 6 month
2. Subject with BMI of >30.
3. Subject with any kind of musculoskeletal deformity such as flat foot.
4. Subject with any kind of neurological problem effecting balance.
5. Subject with any kind of lower limb injury in past 6 month, effecting participation in the study

All participants gave their consent for participation in the study.

Procedure:
A pilot study performed on 10-15 overweight individuals confirmed the existence of postural instability in overweight individuals, having balance problem in normal ADL activity.

All subjects were required to complete a battery of balance test to evaluate their ability to complete balance training programme. These test comprised of

a unipedal stance test and SEBT. Form and technique were observed throughout and used to identify completion of the tests.

Pre test for static and dynamic balance as measured by unipedal stance test and star excursion balance test respectively was performed for all the groups. Subject in intervention groups performed warm up stretching exercise such as tip-toe walking, forward and backward leg swing, saggital plane swing. Following war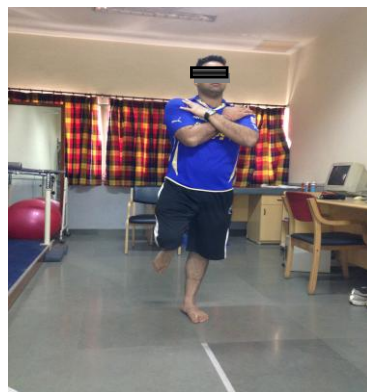m-up, intervention group (both EG) underwent their respective training (virtual reality and conventional balance training).

Duration of training: - Balance training was performed thrice a week sessions for 6 week consisting of fixed foot and functionally directed balance training, each of half an hour of duration. Post test reading were taken after every 2 week of training.

MATERIALS;- Nintendo wii fit virtual reality program & Wii Balance Board, Record sheet,weighing machine, Stopwatch, Micro pore & Pen, Marker, Measuring tape

Virtual reality training   **Unipedal stance test**   **Star excursion balance (SEBT) test**

	Virtual reality (Wii-Fit Nintendo)			Traditional program		
Week 1st and 2nd	Games	Sets	Duration	Exercise	Sets	Rep/Duration
	Ski Slalom	3	12 min	Single leg stance	3	18sec
	Table Tilt	3	12 min	Controlled inversion/eversion	2	14sec
	Balance Bubble	3	12min	Controlled plantar flexion/dorsiflexion	2	14sec
Week3rd and 4th	Ski Slalom	3	12min	Single leg stance	3	28sec
*Advance phase	Table Tilt	3	12min	Single leg squat	4	8sec
	Balance Bubble	3	12min	4- point star	4	8sec
Week 5th & 6th	Ski Slalom	3	12min	Single leg stance	3	35sec
*Advance phase	Table Tilt	3	12min	¼ squat to raise	3	15sec
	Balance Bubble	3	12min	Single leg hip hike	3	15sec

Minimum attempt 4 min maximum 5 minutes.
*Progressed when the subject able to complete initial phase.

Data analysis

Datas were analyzed with the help of statistical package for social sciences (SPSS) version 19. Paired sample t-tests were performed to examine pre and post test differences among individual measurements for all groups in every 2 week reading. Analysis of variance (ANOVA) tests were run for the examined between group performances for each pre and post testing every 2 week till 6 week measurement.

RESULTS

This includes the results obtained after statistical analysis of data of control, virtual reality and traditional balance training group.

Table-1				
	Group	N	Mean	Std deviation
Age	VRG	20	25.6000	.77256
	TBG	20	25.6000	.47240
	CG	20	26.6500	.20869
BMI	VRG	20	27.7865	.37580
	TBG	20	26.5000	.30992
	CG	20	26.0190	.11636
LL	VRG	20	88.4000	1.17965
	TBG	20	85.5500	1.39638
	CG	20	92.4750	1.21258

Table 1 Descriptive information of subject among the age, BMI, limb length among virtual reality, traditional and control balance training group.
VRG.-Virtual reality group, TBG- Traditional balance group, CG- Control group

Table 1 shows descriptive information of Age, BMI, LL of the subjects among VRG, TBG and CG. For VRG mean and S.D value of Age was 25.60±0.77 yr, mean and S.D value of age in TBG was 25.60±0.47yr, and mean and S.D value of Age in CG was 26.65±0.20. For the BMI the mean and S.D value in VRG was 27.78±0.37kg/cm^2, And in TBG the mean and S.D was 26.50±0.30 and in the CG the value of mean and S.D was 26.01±0.11.For LL the mean and S.D of VRG was 88.40±1.17.and in TBG the mean and S.D was 85.55±1.39 and in CG the value of mean and S.D was92.47±1,21cm.In all the group, the mean values were found they have no statistically significant difference.

WITH IN GROUP ANALYSIS

Table 2 shows the comparison of intra group standard Deviation of the pre test and intervention after 2 weeks, 4weeks, and post 6week of SEBT,UPSTEOP and UPSTECL between the VRG,TBG and CG, and further comparison of the mean inter group between the pre reading, after 2week,4week, and 6weeks in the groups. The variations in VRG and CG was non significant and in TBG the variation and p value was more significant. Hence improvement of SEBT, UPSTOP and UPSTCL in balance was significant.

Table No .2					
	GROUP	PRE	A2W	A4W	A6W
SEBT	VRG	5.8775 ±.17	5.8685±.13	5.881±.13	6.031±.15
	TBG	5.9835±.22	6.269±.22	6.5685±.22	6.862±.24**
	CG	6.5565±.23	6.572±.23	6.6195±.23	6.6675±.23
UPSTEOP	VRG	0.39±.05	0.47±.10	0.8±.23	0.73±.09**
	TBG	0.39±.04	0.45±.04	0.68±.05**	0.96±.05**
	CG	0.34±.01	0.37±.01*	0.4±.01**	0.43±.01**
UPSTECL	VRG	0.0840±036	0.0815±.021	0.3190±.25	0.0985±.007
	TBG	0.0495±.005	0.0710±.007	0.1200±.01	0.1380±.013**
	CG	0.0515±.004	0.0670±.005	0.0740±.00	0.0710±.004**

Table 2. All SEBT, UPSTEOP and UPSTECL data Mean ± SEM, where n=20, Data were analysed by One-Way ANOVA with post test analysis by Bonferroni's test at $p \geq 0.05$.
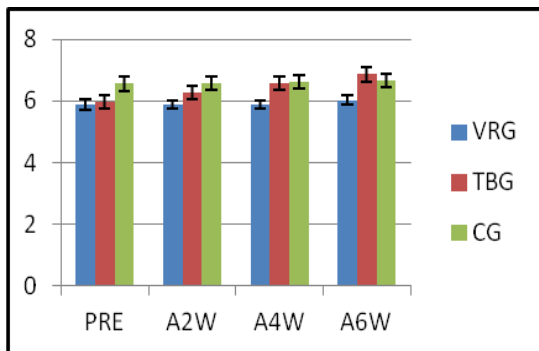

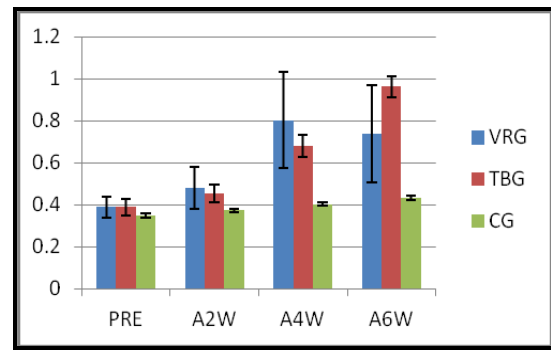Fig. 1 shows SEBT variation between 2 week 4 week and 6week in VRG,TBG and CG

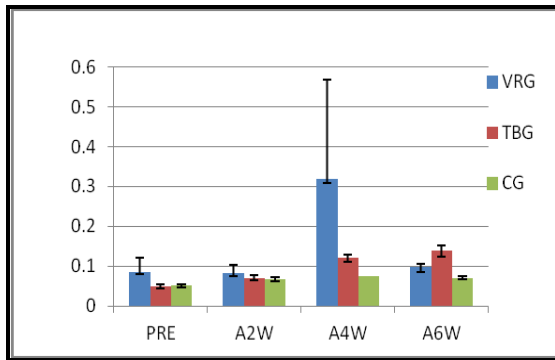Fig 2 shows UPST eyes OPEN variation between 2 week 4 week and 6 week in VRG,TBG and CG

Fig 3 shows UPST eyes closed variation between 2 week 4 week and 6 week in VRG, TBG and CG.

DISCUSSION

The purpose of the study was to determine if virtual reality balance training or traditional balance training can affect balance in over weight individual.

The result of the present study demonstrated that among all the three groups i.e. Control, virtual reality and Traditional balance group, Control Group and Virtual reality group showed a comparative execution in both the deliberate variable and Traditional balance offer climb to more measurable change.

In this study results show that tallness and leg length were absolutely identified with execution on the SEBT. The significance of normalizing excursion distance data was delineated by the presence of huge distinction in excursion distance between sexes on excursion distance score; however an absence of gender difference was found after standardization of excursion distance to leg length. At the point when utilizing the SEBT as evaluation instrument, thought for standardization ought to incorporate leg length .This incorporate either normalizing outing information to leg length or coordinating combined interests for leg length.

Findings of the present study demonstrated impact on balance following six week balance training, no noteworthy distinction in Control Group, Virtual Reality Group noted, however Traditional balance Group showed huge contrast. These outcomes were not so compelling if there was an occurrence of overweight individual in virtual reality, balance preparing yet successful in the event of traditional parity preparing group. The absence of measurably noteworthy contrasts is an offset in virtual reality test group in light of the fact because of learning impact of the diversion in the subjects. According to Erik A. Wikstrom (2012) Wii Fit balance movement scores had poor simultaneous legitimacy with respect to COP results and SEBT achieve separations. Tsung-Yen Chuang et al (2009) said PC based feature amusements were connected to cognitive change. The outcomes from this study gave exploratory proof to support that the utilization of virtual reality based feature amusements can encourage understudies' cognitive learning effect.

In the present study, post intercession SEBT Composite scores in Traditional group demonstrated a factually exceedingly significant contrasts (p=.001) with the most astounding mean worth watched and SLSTEOP likewise indicated very noteworthy contrasts (p=.001) in all the three groups. There was a critical contrast in SLSTECL among Control and Traditional balance group whereas it was non significant in virtual balance group.

The plausible reasons of dynamic balance expand due to traditional balance training as measured by SEBT could be because of; Change in muscle quality of subject, power on neuromuscular framework, activating tactile receptor as overweight young men have lower quality with respect to mass.

Discovering the intergroup shrewd examination, it demonstrated that there was a factually huge contrasts in the post-intercession SEBT and SLST composite score between Control Group and traditional Group and virtual balance preparing, In SEBT the contrast between control group and virtual reality offset preparing group was not noteworthy, this could be because of

the reason that there was no critical solid association in the preparation in present study. What's more, in the traditional balance preparing having huge solid association, In the SLSTEOP and SLSTECL additionally having same as in SEBT parity impact in all the groups. In the virtual reality parity preparing group adjust not critical enhancing, this could be learning impact of the amusement level. Results of the present study demonstrated that there was a huge distinction between the traditional and virtual reality balance group. The reasons could be the strong adjustment in proprioception and also improvement of neuromuscular system calculates better result in conventional parity group.

The after effect of inside group examination of variables of the control group in this study demonstrated a factually no noteworthy contrast in the middle of pre and post mediation estimation of SEBT, SLSTEOP and SLSTECL composite score. The reason behind this could be no specific training which subjects in this group has followed.

Discoveries of this examination demonstrated that virtual reality group demonstrated a practically consistent SEBT composite score following six week. Results of present study declared some decline in SLSTEOP and SLSTECL composite score, possible reason could be due to abatement learning impact of the diversion or changes in weight of the subjects during six weeks duration.

This study demonstrated that there is a factually exceedingly noteworthy contrast between the pre intervention and post mediation score of SEBT, SLSTEOP and SLSTECL in conventional offset preparing group (p=0.001). The change in variable shows that adjustment identifying with increment in leg quality and proprioception and strong coordination and solid control.

This is the first research to discriminatingly dissect the adequacy of feature amusement based on parity preparing projects in overweight individuals. Prior explorations studies have demonstrated that adjust projects have demonstrated successful in enhancing balance estimations in a mixture of settings. [1,2]

This study demonstrate the consequences of those past studies, however rather gives positive confirmation of viability to the clinician who decides to utilize feature diversion based exercises as a part of their parity preparing projects. In this study, conventional parity program cooperation fundamentally enhanced two of the three tried Star Excursion Balance exercises from pre to post testing. It ought to be brought up that these territories of change were noted in exercises that were additionally utilized as a preparation activity amid the 4-week preparing period. It is a particular plausibility that a preparation impact happened from these exercises. Then again, in spite of their adequacy, traditional offset programs regularly evoke understanding agreeability troubles. It is likewise imperative to note that in this study the conventional parity project had the least watched scores for patient engagement and pleasure. This affirms the suspicions and concerns of past scientists in regards to the consistence in traditional balance programs. [2]

Task chosen which was similar to everyday life activities were selected. Ascending from a situation to a standing position is a standout amongst the most widely recognized exercises of day by day living. In the event that youngsters are less fit for lifting the body from sitting to standing on account of abundance fat mass, they may pick not to remain as regularly. Amid a sit to stand test, generous leg quality and a sufficient scope of joint movement are obliged, representing an impressive test to adjust. [5,25]

Prior study in obese youthful youngsters showed diminished lower

appendage usefulness obstructed their capacity to ascend from a chair. [22] Higher BMI youngsters invested altogether additional time amid all exchange periods of the rising assignment contrasted and the non-fat kids, and most corpulent subjects moved their trunk regressive before starting the trademark forward and upward movement to stand. Our discoveries are in concurrence with these discoveries. Overweight young men demonstrated slower weight exchange and a lower rising file (communicated in % body weight) amid the sit to stand test on the weight plate contrasted and typical weight partners. This inward compel creation in raising the body to a standing position may be because of deficient leg quality to lift the overabundance body weight. Overweight young men likewise had more prominent influence speed in standing position, showing that they experience issues decelerating the forward trunk movement taking after the ascent. It could be additionally an outcome from lower quality with respect to mass. Overweight young men were likewise slower when performing a numerous sit-to-stand field test. As the different sit-to stand test is frequently utilized as a marker of leg speed and force. [6] This poorer execution in the various sit-to-stand test in overweight young men is in concurrence with their lower rising record on the power plate.

SEBT includes amplifying lower limit achieve separation with one appendage while keeping up parity on the contralateral appendage. Coherently leg length would correspond altogether with outing separation, as a more extended appendage would give member leverage in coming to that appendage further. What's more, on the grounds that stature and leg length firmly associate with one another, it is intrinsic that tallness and outing separation would likewise relate fundamentally.

The relations for tallness and leg length to outing separation were critical, they were not particularly solid. The most elevated connections happened between leg length and journey remove in the three foremost headings (front, anterolateral, anteromedial), This demonstrates that while leg length is a huge indicator of execution on the SEBT, different calculates not evaluated for this study, represent most of the change connected with journey distance. [7]

In a static balance of postural control, the objective is to minimize uprooting of the core of weight, a subsidiary of the vertical ground response power. In the measure of element postural control utilized as a part of this study, the objective is to augment achieved separation while keeping up one-sided support. The inside of weight trip could be influenced by the measure of ground contact identified with foot sort. Postural influence is not evaluated in the SEBT, however it is innate to the test that some moving of the inside of weight will jump out at augment journey separation. Foot sort, nonetheless, did not fundamentally influence the execution of the SEBT, perhaps because of other compensatory movements or coming to techniques, or both, that permit a subject to conquer a shortfall possibly because of foot type. [7]

Impediment of the study
The study incorporate middle age group and physically fit overweight single person.

Age group is variable (18-36) so that as indicated by the few musculoskeletal and physiological changes happening which can prompt balance issue.

Term of the study was six weeks, because in this length of time BMI changes are possible so adjustment can be hampered.

Test incorporating in the study was populace generally 20-30 yr, so the outcome

cannot be summed up to middle age populace group.

Limitations of study

During the 6 week Duration of the study BMI was not reassess as there were high chances of changes in subject BMI score due to changes in weight.

The reliability and validity of Nintendo Wii Fit balance program according to the previous study is poor.

Games for the balance training in Nintendo Wii-Fit was highly susceptible of adaptation which shows learning effect in subjects thus produces less improvement.

Future Research

This study could be possible on corpulent individual as just overweight individual were utilized as a part of the present study.

This study can be utilized for biomechanical amendment and expanded the strong co appointment.

This study can help in athletic populace by expansion the term of convention as indicated by the games particular.

CONCLUSION

The study implies the utilization of conventional balance preparing in six week to improve the static and element adjust in overweight people and lessen the shot of harm in action of everyday living.

With the assistance of this preparation typical populace individual keep up wellbeing and fitness, which can decrease the shot of damage keep up and enhance personal satisfaction in day by day action.

Clinical significance

The finding of the present study may presume that traditional parity preparing group having a great deal more compelling for the overweight individual, there was not much impact of virtual reality preparing program in the event of overweight populace, it is more successful in neurological anomaly subject as proved by past studies. Furthermore, we are building term of preparing, then its impact on balance is considerably more viable.

REFERENCES

1. Arnold BL, Schmitz RJ. Examination of balance measures produced by the Biodex Stability System. J Athl Train. 1998;33:323-7.
2. Beard D, Refshauge K. Effects of ACL Reconstruction on proprioception and neuromuscular performance. In: Lephart SM, Fu FH, editors. Proprioception and neuromuscular control in joint stability. Philadelphia: Human Kinetics. 2000; 213-24.
3. M. M. Madureira & L. Takayama Balance training program is highly effective in improving functional status and reducing the risk of falls in elderly women with osteoporosis: a randomized controlled trial. Int Osteoporosis. 2007;18:419–425
4. Valmassy RL. Biomechanical evaluation of the child. In: Valmassy RL (ed.). Clinical Biomechanics of the Lower Extremity. Mosby: London. 1996; 243–277.
5. Bernard PL, Geraci M, Hue O, Amato M, Seynnes O, Lantieri D. Influence of obesity on postural capacities of teenagers. Preliminary study. Ann Readapt Med Phys. 2003; 46: 184–190.
6. Thompson GH, Carter JR, Smith CW. Late-onset tibia vara: a comparative analysis. J Pediatr Orthop. 1984;4: 185–194.
7. Campbell AJ, Borrie MJ, Spears GF. Risk factors for falls in a community based prospective study of people 70 years and older. J Gerontol A Biol Sci Med Science.1989;44:112–17.
8. Middlemas DA, Basilicato J, Prybicien MA, Savoia J, Biodoglio J. Incorporating gaming technology into athletic injury rehabilitation. Athl Train Sports Health Care. 2009;1(2):79–84.
9. Thapa PB, Gideon P, Fought RL, Kormicki M, Ray WA. Comparison of clinical and biomechanical measures of

balance and mobility in elderly nursing home residents. J Am Ger Soc. 1994;42:493-500.

10. Goulding A, Jones IE, Taylor RW, Piggot JM, Taylor D. Dynamic and static tests of balance and postural sway in boys: effects of previous wrist bone fractures and high adiposity. Gait Posture. 2003;17:136–141.

11. Emery, CA, Rose, MS, McAllister, JR, and Meeuwisse, WH. A prevention strategy to reduce the incidence of injury in high school basketball: A cluster randomized controlled trial. Clin J Sport Med. 2007;17:17–24.

12. Campbell AJ, Robertson MC, Gardner MM et al. Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. BMJ. 1997;315:1065–1069.

13. Saposnik G, Teasell R, MamdaniM, et al. Effectiveness of virtual reality usingWii gaming technology in stroke rehabilitation: a pilot randomized clinical trial and proof of principle. Stroke. 2010;41(7):1477–1484.

14. Jones G, Glisson M, Hynes K, Cicuttini F. Sex and site differences in cartilage development: a possible explanation for variations in knee osteoarthritis in later life. Arthritis Rheum. 2000; 43: 2543–2549.

15. Saposnik G, Teasell R, MamdaniM, et al. Effectiveness of virtual reality usingWii gaming technology in stroke rehabilitation: a pilot randomized clinical trial and proof of principle. Stroke. 2010;41(7):1477–1484.

16. Riley PO, Schenkman ML, Mann RW, Hodge WA. Mechanics of a constrained chair-rise. J Biomech.1991;24:77- 85.

17. Weinstein AR, Sesso HD, Lee IM, Cook NR, Manson JE, Buring JE, et al. elationship of physical activity vs body mass index with type 2 diabetes in women. JAMA. 2004;292: 1188-94

18. Finkelstein EA, Chen H, Prabhu M, Trogdon JG, Corso PS. The relationship between obesity and injuries among U.S. adults. Am J Health Promot. 2007;21:460–468.

19. Middlemas DA, Basilicato J, Prybicien MA, Savoia J, Biodoglio J. Incorporating gaming technology into athletic injury rehabilitation. Athl Train Sports Health Care. 2009;1(2):79–84

20. Chung SM, Batterman SC, Brighton CT. Shear strength of the human femoral capital epiphyseal plate. J Bone Joint Surg.1976;58A: 94–103.

21. Era, P, Sainio, P, Koskinen, S, Haavisto, P, Vaara, M, and Aromaa, A. Postural balance in a random sample of 7,979 subjects aged 30 years and over. Gerontology.2006;52: 204–213.

22. Erik A. W Validity and Reliability of virtual reality Balance Scores. Journal of Athletic Training.2012;47(3):306–313

23. Gribble P A, Hertel jay considerations for normalizing measures of the star excursion balance test, measurement in physical education and exercise science.2003;(2):89-100

24. Mcguine t a, keene j s the effect of a balance training program On the risk of ankle sprains In high school athletes, the american journal of sports medicine.July 2006; 34 :1103-1111

25. Bohannon W. Sit-to-stand test for measuring performance of lower extremity muscles. Perc Mot Skills. 1995;80:163-166.

****