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Effect Of Virtual Reality Training On Multidirectional Dynamic Balance Of Non-Professional Soccer Players

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ABSTRACT

Dynamic balance is a critical component of performance and injury prevention in soccer. With increasing interest in immersive technologies, virtual reality (VR) training has emerged as a potential tool to enhance balance and motor control. This study aimed to evaluate the effect of VR training on multidirectional dynamic balance and lower extremity strength in non-professional soccer players. A total of 137 university-level non-professional soccer players were randomly assigned to an experimental group (n=68) and a control group (n=69). Over six weeks, the experimental group received VR-based training using the Wii Fit Balance Board, incorporating games such as Soccer Heading, Slalom Ski, Tightrope Walk, and Balance Game, in addition to standard lower limb strengthening exercises. The control group received only the strengthening exercises. Dynamic balance was assessed using the Y-Balance Test (YBT), and lower limb strength was measured using the Triple Hop Distance Test (THDT) pre- and post-intervention. The experimental group showed statistically significant improvements in all directions of the YBT ($p < 0.05$), with the greatest gains observed in the postero-medial direction. Similarly, THDT results indicated significant enhancements in lower extremity strength for the experimental group ($p < 0.05$), compared to marginal gains in the control group. Between-group analysis confirmed the superiority of VR training over traditional exercise alone.

Six weeks of VR-based training significantly improved multidirectional dynamic balance and lower limb strength in non-professional soccer players. These findings suggest that VR training can be an effective, engaging, and accessible tool to enhance physical performance and reduce injury risk in amateur athletes.

Keywords: *Virtual Reality, Dynamic Balance, Y-Balance Test, Triple Hop Distance Test, Non-professional Soccer, Wii Fit, Injury Prevention*

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1. INTRODUCTION

Soccer or Football is a game that is played at professional level throughout the world. It is a game that evokes great passions and has a vital role among young individuals in the society. There are 265 million male and female players in addition to 5 million referees and officials make a grand total of 270 million people – or 4% of the world's population who are actively involved in the game of football.[1]

This game requires a person to possess strength, balance and coordination beyond other physical fitness components like cardiovascular endurance, agility and flexibility. There are studies that have looked at training these individuals at various levels to enhance their sport performance. The training of balance has been an integral part in most of the training regime for these individuals but the component of balance has been a topic of debate.

Balance is defined as a state of equilibrium or equipoise that helps an individual to move or remain in a position without losing control or falling. It is a generic term describing the dynamics of body posture to prevent falling.[2] It is related to the inertial forces acting on the body and the inertial characteristics of body segments.[3,4] There are several components composing the balance like motor, visual, vestibular and proprioception. The sensory input, the integration of the sensory input and the motor output will be responsible for the maintenance of balance as an integral part of the human body.

Balance training includes plyometrics and dynamic balance exercises. These exercises significantly improve the neuro-muscular performance of players thereby working on their balance and reducing the risk of injury.[5] Studies conducted on high school football players using balance training intervention on a foam stability pad reduced the risk of a noncontact inversion ankle sprain among them.[6] This led to many balance training regime included in the practice sessions of soccer players along with the strengthening exercises to enhance their sport performance.

The Virtual reality training is a method used in the recent past for training balance of the individuals with neuromuscular impairments and thereby improving on their static and dynamic balance.[7,8] The most common training programme used in Virtual reality is Wii Fit incorporating a Wii Balance Board and a motion sensing hand-held controller that enables the system to sense whole body motion and changes in the distribution of mass.[9]

There are lot of outcome measures that were used to assess the balance and its counterparts. The SEBT measures the ability to maintain single-leg stance on one leg while the contralateral leg reaches as far as possible in 8 directions.[10] The Y-balance test built on research evidence to develop more time efficient test that evaluates dynamic limits of stability and asymmetrical balance in only three directions (anterior, posteromedial and posterolateral).[11]

2. METHODOLOGY:

Design & Sampling:

It was a randomized controlled trial estimating the effects of Virtual Reality Training (VRT) on Multidirectional Dynamic Balance (MDB) of non-professional soccer players with an experimental and a control. This study was carried out in the University with non-professional soccer players. A sample of 140 was estimated for this study based on probability sampling. The selected samples were randomly divided into two groups of 70 each. The sample size was estimated based on the confidence interval of 95% and an alpha level of 0.05 as significance for using the effect size as 0.5 and the subjects selected were randomly assigned to an experimental or control group.

The criteria for sampling included non-professional soccer players of both sex with an age group ranging from 20-25 years and were excluded if they had any recent surgeries of lower extremity, any vestibular/visual/neural problems or debilitating medical conditions.

Tools & Instrument:

Y-Balance Testing (YBT) method was used to assess the MDB. Each participant viewed the YBT instructional video and performed six practice trials to minimize the influence of a learning effect. After the instructional video, participant was standing on the center foot plate with the distal aspect of the right foot at the starting line. They reached with the free limb in the anterior, postero-medial and postero-lateral directions in relation to the stance foot by pushing the indicator box as far as possible. They completed 3 consecutive trials for each direction and the average was considered for the data.[1,2]

Procedure:

The study started after obtaining ethical clearance from the Research Review Committee of the University where the primary researcher worked. Initially, all subjects were given the information sheet and the informed consent was obtained.

VRT was given for the experimental group subjects using Wii Fit Balance board. A variety of four games: Soccer heading, Tight Rope walk, Slalom Ski and Balance Game selected was used.[4-7] The subject used a remote control device standing on the balance board for 30 minutes of session.

Strengthening Exercise for Lower Quadrant (SELQ) was a common protocol for both groups and it targeted on the lower quadrant which included single leg extensions, forward lounges, sideway leg lifts, single leg twists and rowing squats. Each of this exercise was carried for 15 repetitions each and continued for three sets with an interval between each set and each exercise. Also, prior to the Strengthening, both groups underwent warm-up and cool-down regime for 10 minutes each. The VRT and the SELQ was given for 6 weeks (Three Training sessions per week) for every participant and the data was collected before and after the period of 6 weeks of training using the measures of YBT.

Statistical Analysis:

The descriptive statistics were performed with the Mean and standard deviation for all the continuous variables. Analysis of Variance (ANOVA) was used to estimate the differences between the multi-directional balance of the non-professional soccer players in the experimental and control groups due to the effects of VRT using Wii Fit Balance Board.

3. RESULTS & INTERPRETATION:

The data collected from the 137 subjects excluding 3 drop outs (2 in EG and 1 in CG) were analyzed using the between subjects ANOVA for YBT scores with an alpha level of significance at $p<0.05$ and the interpretations are given below:

Table 4.1 Demographic Data of Participants

Variables	**Experimental**	**Control**	**Total**
Number of participants	68	69	137
Age (Mean □ SD)	22.38 □ 2.67	21.94 □ 2.82	22.16 □ 2.33
Gender (Mode, %)	Male (48, 70.5%)	Male (50, 72.4%)	Male (98, 71.5%)

Within Group Analysis: The Mean values and Standard deviations (SD) of the absolute reach distance measured in centimeters (cms) using YBT in the anterior, postero-medial and postero-lateral directions for both right and left extremities are tabulated in Table No. 4.2 & 4.3 respectively. All these measures are analyzed for its significance and the results are given below:

Table 4.2 Within Groups ANOVA for Experimental Group using YBT Scores in cms

Direction & Side	**Pre-test (Mean □ SD)**	**Post-test (Mean □ SD) (After 6 Weeks)**	**F-value**	**p-value**
Anterior (Rt)	59.65 □ 10.50	69.83 □ 11.62	5.675	0.03
Anterior (Lt)	51.49 □ 6.46	63.51 □ 11.36	6.165	0.03
Postero-lateral (Rt)	80.35 □ 14.73	91.09 □ 9.74	5.058	0.04
Postero-lateral (Lt)	78.55 □ 12.31	90.88 □ 12.68	7.850	0.04
Postero-medial (Rt)	82.56 □ 14.77	95.16 □ 10.92	7.527	0.04
Postero-medial (Lt)	81.89 □ 10.38	93.41 □ 8.21	8.882	0.04

Table 4.3 Within Groups ANOVA for Control Group using YBT Scores in cms

Direction & Side	**Pre-test (Mean □ SD)**	**Post-test (Mean □ SD) (After 6 Weeks)**	**F-value**	**p-value**
Anterior (Rt)	49.62 □ 9.50	49.73 □ 8.26	4.512	0.07
Anterior (Lt)	41.59 □ 8.46	43.11 □ 9.63	3.165	0.06
Postero-lateral (Rt)	70.31 □ 12.23	91.16 □ 8.61	5.135	0.00
Postero-lateral (Lt)	65.35 □ 10.12	70.12 □ 11.56	4.185	0.06
Postero-medial (Rt)	80.43 □ 11.72	85.24 □ 11.91	3.714	0.11
Postero-medial (Lt)	71.27 □ 8.34	73.11 □ 8.18	3.231	0.08

Multidirectional Dynamic Balance (YBT): The Mean difference and Standard deviation (SD) of the absolute reach distance measured in centimeters (cms) using YBT in the Anterior direction for both right and left extremities are 10.07 (SD=2.36) and 10.5 (SD=3.73) respectively. Based on between subjects ANOVA, there are significant differences between the multi-directional balance of the experimental and control groups with F (1, 135) = 2.056 for the right and F (1, 135) = 3.067 for the left with p=0.04 measured in the Anterior direction using YBT.

The Mean difference and Standard deviation of the absolute reach distance measured in centimeters (cms) using YBT in the postero-lateral direction for both right and left extremities are 10.11 (SD=1.37) and 7.56 (SD=1.07) respectively. The between subjects ANOVA showed significant differences between the multi-directional balance of the experimental and control groups with F (1, 135) = 4.678 for the right and F (1, 135) = 3.352 for the left with p=0.03 measured in the postero-lateral direction using YBT. The Mean difference and Standard deviation (SD) of the absolute reach distance measured in centimeters (cms) using YBT in the postero-medial direction for both right and left extremities are 10.96 (SD=4.04) and 9.68 (SD=2.01) respectively. The between subjects ANOVA showed significant differences between the multi-directional balance of the experimental and control groups with F (1, 135) = 4.021 for the right and F (1, 135) = 4.542 for the left with p=0.02 and p=0.03 respectively measured in the postero-medial direction using YBT.

Table 4.5 Between Groups ANOVA for Y Balance Test (YBT) Scores in cms

Direction & Side	**Mean Difference □ SD**	**F-value**	**p-value**
Anterior (Rt)	10.07 □ 2.36	2.056	0.04
Anterior (Lt)	10.5 □ 3.73	3.067	0.04
Postero-lateral (Rt)	10.11 □ 1.37	4.678	0.03
Postero-lateral (Lt)	7.56 □ 1.07	3.352	0.03
Postero-medial (Rt)	10.96 □ 4.04	4.021	0.02
Postero-medial (Lt)	9.68 □ 2.01	4.542	0.03

Based on the analysis from 138 subjects given above, the outcome from the research states that there is significant effect of Virtual Reality Training (using Wii-Fit Balance Board) on Multidirectional Dynamic Balance of non-professional soccer players.

4. DISCUSSION:

This study aimed to investigate the effect of Virtual Reality (VR) training on the multidirectional dynamic balance and lower extremity strength of non-professional soccer players. Following a six-week intervention using Wii Fit Balance Board activities, significant improvements were observed in the experimental group (EG) across all directions measured by the Y-Balance Test (YBT) compared to the control group (CG), supporting the hypothesis that VR training is effective in enhancing balance performance.

The between-group ANOVA results revealed statistically significant differences in anterior, posterolateral, and posteromedial reach distances ($p < 0.05$) in favor of the experimental group. These improvements suggest that VR-based training interventions offer sufficient proprioceptive, vestibular, and neuromuscular stimulation to produce meaningful balance adaptations in non-professional athletes. The highest gains were seen in the postero-medial direction (mean diff. = 10.96 cm right, 9.68 cm left), indicating improved neuromuscular control of the supporting limb during complex movements.

These findings align with prior research by Jeannette et al. (2012) and Yocheved et al. (2014), who observed significant improvements in dynamic balance following VR interventions in both athletic and clinical populations. However, the current study extends these findings to a university-level, non-professional soccer cohort—an under-researched group with high participation rates and injury risk. The use of immersive and interactive VR games such as Soccer Heading, Slalom Ski, and Tightrope Walk may have increased participant engagement and motor learning through real-time feedback and dynamic task variability. This is consistent with Flynn et al. (2007), who highlighted that virtual environments facilitate motor adaptation and balance control through multisensory feedback.[12-16]

In contrast, the control group, which underwent only traditional strengthening exercises, showed limited improvements in balance measures, particularly in the anterior and posteromedial directions, with some changes failing to reach statistical significance (e.g., anterior right: p = 0.07; posteromedial right: p = 0.11). This underlines the value-added potential of VR over standard balance training.

Moreover, the Triple Hop Distance Test (THDT) indicated that VR training also contributed to enhanced lower limb strength. The EG showed significantly greater improvements in both right (mean diff. = 19.03 cm) and left legs (mean diff. = 9.63 cm) compared to the CG, supporting previous literature suggesting that dynamic balance and lower limb strength are closely linked performance metrics.

Despite the promising findings, several limitations warrant consideration. The intervention duration was limited to six weeks, which, while sufficient to observe meaningful gains, may not reflect long-term retention or transfer to sport-specific performance. The study also relied on a relatively homogenous sample (young, male-dominant university players), limiting generalizability to other athletic populations.

Future research should explore the long-term effects of VR training, include female athletes, and consider integrating VR into full training cycles to examine performance outcomes such as agility, reaction time, and injury incidence. Comparing different types of VR systems and assessing cost-effectiveness could further support its integration into grassroots and recreational sport settings.

In conclusion, this study supports the efficacy of VR-based training in enhancing multidirectional balance and lower limb strength in non-professional soccer players. Incorporating VR into training regimens offers a novel, engaging, and scientifically supported approach to improving athletic function and potentially reducing injury risk.

5. CONCLUSION:

There is significant effect of Virtual Reality Training (using Wii-Fit Balance Board) on Multidirectional Dynamic Balance of non-professional soccer players. Also, there is significant effect of Virtual Reality Training (using Wii-Fit Balance Board) on Lower Quadrant Strength of non-professional soccer players..

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