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Effectiveness of Virtual Reality Based Training on Balance and Footwork Among Beginner Badminton Players: An Experimental Study

Prajwal Gaikwad[1], Dr. Unika Purohit[2]

[1]BPT Intern, P.E.S. Modern College of Physiotherapy, Pune, India,
[2]Associate Professor (Sports Physiotherapy), P.E.S. Modern College of Physiotherapy, Pune, India

Corresponding Author: Prajwal Gaikwad

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ABSTRACT

BACKGROUND: Virtual reality is a simulated experience that employs pose tracking and 3D near-eye displays to give the user an immersive feel of a virtual world. Competitive badminton engages a wide variety of postural changes including jumps, lunges, quick changes in direction, and rapid arm movement required for reaching shuttle in as few steps as possible while maintaining good balance and keeping the body under control.

AIM & OBJECTIVE: To check the effectiveness of Virtual Reality Based Training on Static balance and Dynamic Balance using Unipedal Stance Test and Star Excursion Balance test respectively among beginner badminton players at the end of 6 weeks.

METHOD: Subjects were taken from PDMBA sports complex as per inclusion and exclusion criteria. Initial evaluation of balance and footwork will be done at 0 week and post assessment of balance and footwork will be done at the end of 6 weeks. 3 times a week for 6week time 30-45 minutes per session.

RESULT: After 6weeks of VR training the subjects showed improvement in balance. ($p<0.05$, paired t-test).

CONCLUSION: VRBT can be used with traditional badminton training to improve players performance.

KEYWORDS: Virtual Reality Based Training, Static Balance, Dynamic Balance, Beginner Badminton Players, Unipedal Stance Test, Star Excursion Balance Test.

INTRODUCTION

Virtual reality (VR) is a simulated experience that employs pose tracking and 3D near-eye displays to give the user an immersive feel of a virtual world. Applications of virtual reality include entertainment (particularly video games), education (such as medical or military training), business (such as virtual meetings) and medial field (surgery training, physical therapy). Currently, standard virtual reality systems use either virtual reality headsets or multi-projected environments to generate some realistic images, sounds and other sensations that simulate a user's physical presence in a virtual environment. A person using virtual reality equipment is able to look around the artificial world, move around in it, and interact with virtual features or items.[1] Use of games with the biofeedback system, such as the virtual reality (VR) system, is widely used for rehabilitation. It is due to the fact that the VR system can make the treatment more

interesting, reduce the difficulty of rehabilitation, and increase safety.[2]

Badminton is a sport that requires fast and powerful shots and agile footwork. It is one of the fastest racket sports in the world; the speed of badminton smashes can be as high as 30m/s. In addition, badminton players must react to the moving shuttlecock and adjust their body position rapidly and continuously throughout the game. They must maintain their centre of gravity within the base of support while performing very rapid and asymmetrical upper limb movements. Therefore, greater body balance is crucial for badminton skill advancement, Sports performance, and injury prevention.[3]

Balance refers to an individual's ability to maintain their line of gravity within their Base of Support (BOS). Static Balance is the ability to maintain postural stability and orientation with centre of mass over the base of support and body at rest. Dynamic balance is the ability to maintain postural stability and orientation with centre of mass over the base of support while the body parts are in motion.[4]

Static balance is crucial for a postural control and has an exceptional effect on the performance of sports players and for injury prevention. Badminton requires static balance for the execution of a sports-specific skill like landing from a jump.[5] The badminton players need to make decisions based upon the prediction of the opponents moving direction and the flight trajectory of the badminton in a very short time. This process is closely associated with the capacity of dynamic balance control, including lunges, landing stability and quick adjustment such as acceleration, deceleration, change of direction of the body trunk. The ability to maintain dynamic balance has been linked to increased speed of change of direction, better control of jumping and running to smash, and making the lunges. Therefore, strategies aiming to improve dynamic balance and quickness hold great promise to improve the match performance of badminton players.[6]

Footwork performance is characterized by the ability to accelerate or decelerate and change Directions on the court for accurate shots and better performance. Footwork includes moving to and from six zones of the court (viz. right and left frontcourt, the right and left midcourt, and the right and left rear court) using different stepping strategies, lunge strategies and arm Movements.[7]

MATERIALS & METHODS

PARTICIPANTS: A sample of 28 beginner badminton players were included in the study on basis of predefined inclusion criteria of players with less than 6 months of experience. Age group between 0815years. Both gender male and female. Players taking regular badminton coaching (minimum 3days/week). Exclusion criteria comprised of players with acute injury. Players with Acrophobia. Players with motion sickness. Players with MSK condition. Players with neurological condition. Players with cardiovascular condition.

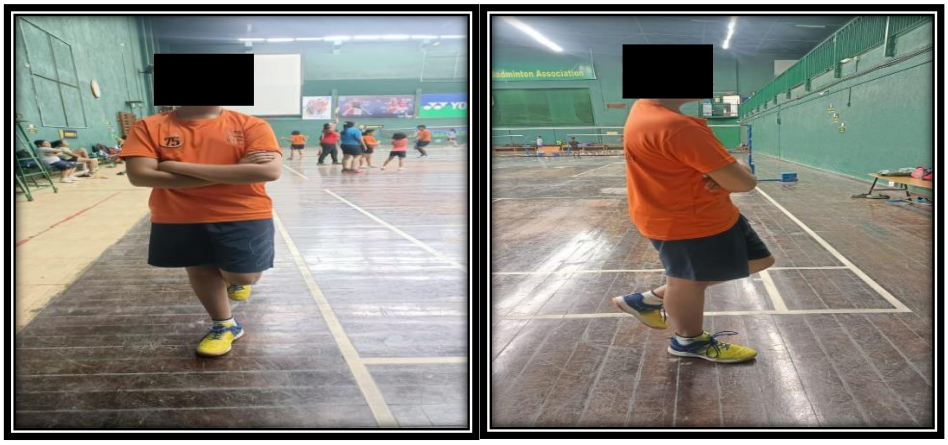
STUDY DESIGN AND RESEARCH SETTING:

The study was designed as an experimental study with a sample size of 28 participants. Convenient sampling method was employed to select the study population, consisting of beginner badminton players. The study was conducted in Badminton academy in and around Pune, Maharashtra, over a period of 6 months. With ethical clearance obtained from the Ethical Committee of PES Modern College of Physiotherapy. The aim of the study was to study the effectiveness of Virtual Reality based training on balance and footwork among beginner badminton players at end of 6weeks. Outcome measures used to collect data were Unipedal Stance Test, Star Excursion Balance Test and Shuttle Run Test. Pre and Post intervention data were collected. Prior to participation, participants were provided with a detailed explanation of the study's purpose and procedures, consent and accent were obtained from each individual and parent. Responses were

recorded, and data was collected and analyzed accordingly.

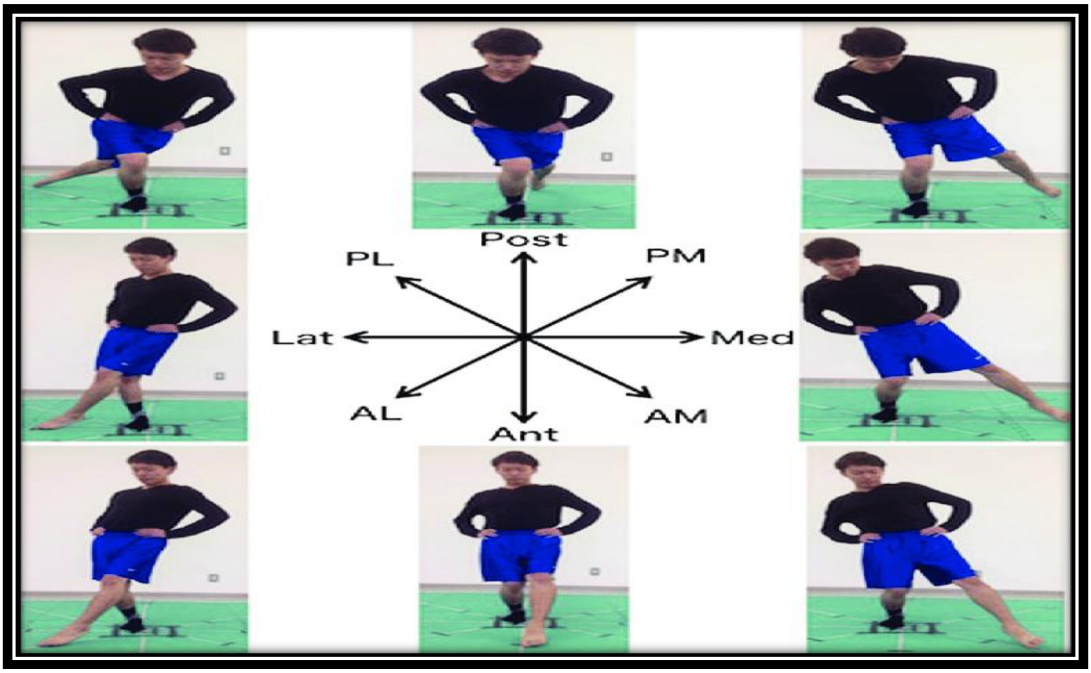
OUTCOME MEASURES:

1. **Unipedal Stance Test** was used to assess static balance of each participant. During the test, participants will be asked to stand on the limb of their choice, with the other limb raised so that the raised foot positioned near but not touching the ankle of their stance limb, with arms crossed over the chest. Each participant will be instructed to focus on a spot on the wall at eye level in front of him, for the duration of the eyes open test. Time calculation commenced using a stopwatch when the participant raised the foot off the floor. Time calculation will end when the participant either: (1) uses his arms (i.e., uncrossed arms); (2) uses the raised foot (i.e., moved toward or away from the standing limb or touched the floor); (3) moves the weight-bearing foot to maintain balance (i.e., rotated foot on the ground); (4) a maximum of 45 seconds is elapsed, or (5) opened eyes on eyes-closed trials. The procedure was repeated 3 times and the best of the three trials was recorded. Participants will perform 3 trials with the eyes opened and 3 trials with the eyes closed, alternating between the conditions. A 5-minute rest will be allowed between each trial set to avoid fatigue.[7] Inter-rater reliability for the best of 3 trials was determined to be excellent with an intra-class correlation coefficient of 0.994 (95% confidence interval 0.989-0.996) for eyes open and 0.998 (95% confidence interval 0.996-0.999) for eyes closed.[8]



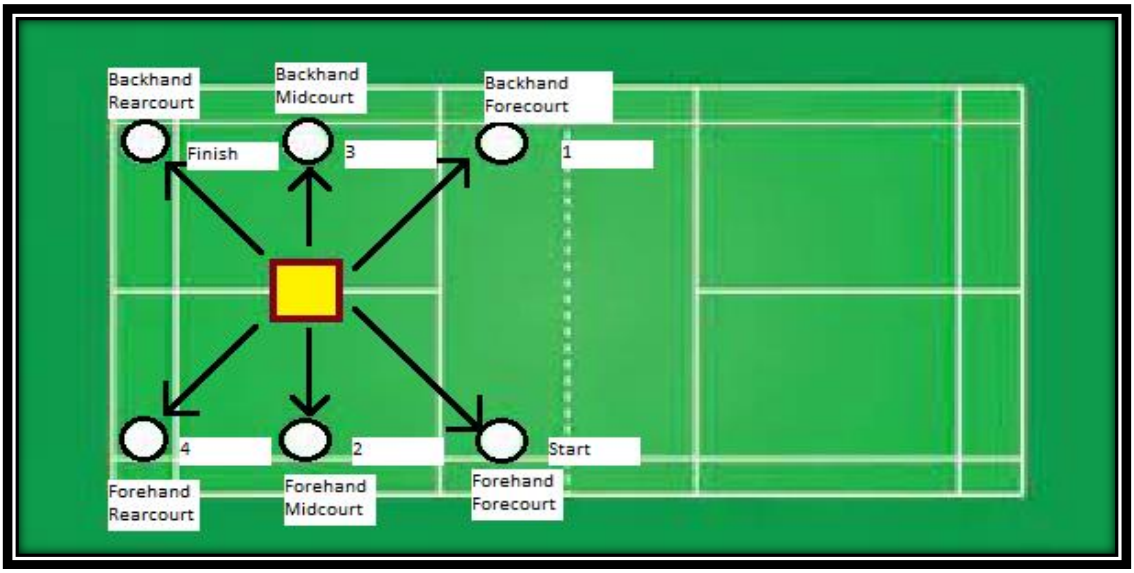
UNIPEDAL STANCE TEST

2. **Star Excursion Balance Test** was carried out to assess the dynamic balance of each participant. During the test, the participants will be asked to stand in the center of the grid of 8 lines with hands on their iliac crests. Then participants will be asked to reach in the clockwise as far as possible along the 8 reaching directions: anterior; anterior-lateral; lateral; posterior-lateral; posterior; posterior-medial; medial; anterior-medial. Participants will be instructed to lightly touch the line with the most distal part of the reaching foot, and return the reaching leg back to double-leg stance, while maintaining a single-leg stance with the other leg in the center of the grid. The reach distances were recorded with a mark on the tape line at the point of maximal reach and will be measured from the center of the grid. The average of three trials will be taken. The trial will be discarded and repeated if the participant uses the reaching leg for a substantial amount of support at any time, removed the weight-bearing foot from the center of the grid, or will be unable to maintain balance on the support leg throughout the trial.[7] Reliability ICC =0.84–0.92.[9]



STAR EXCURSION BALANCE TEST

3. **The shuttle run** is a standard coaching phenomenon and a practice-based protocol. Specifically, the shuttle run mimics sport-specific footwork and therefore best considered a proxy-measure of badminton footwork performance. In the shuttle run circuit set up, three shuttlecocks will be initially placed in the forehand corner of the forecourt. Participant start by picking up each shuttle from forehand forecourt and placed in the backhand forecourt corner, then the forehand sideline, then the backhand sideline, then the forehand backcourt followed by backhand backcourt corner. Each movement was made via the base position at the center-court using the same footwork routine used in real-full court play thus mimicking the footwork in a real game. Total time taken to accomplish all the movements in six directions was recorded. The average of the three shuttle runs will be taken as the shuttle run time. A 6-minute rest was given between two shuttle runs.[7]



SHUTTLE RUN

PROTOCOL:

6 WEEK PROTOCOL WHICH INCLUDE (3DAYS/WEEK):

- Warm Up Exercises 10mins
- VRBT game 20mins
- Cool Down Exercises 10mins

WARM UP EXERCISES:

1. ROM Exercises.
2. Jumping jacks.
3. Spot jogging.

COOL DOWN EXERCISES:

1. Stretching of all muscles.

VRBT GAME:

Playing the virtual reality game in which there are three scenarios:

1. Elevator(6min)

Fig.1 Elevator Scenario in VR for static balance.

Fig.2 Participant playing elevator scene.

2. **City(7min)**

Fig.3 City Scenario in VR for dynamic balance.

Fig.4 Participant playing City scene.

3. **Quarry(7min)**

Fig.5 Quarry Scenario in VR for dynamic balance.

Fig.6 Participant playing Quarry scene.

PROGRESSION:
1st and 2nd week playing level 1.
3rd and 4th week playing level 2.
5th and 6th week playing level 3.

STATISTICAL ANALYSIS

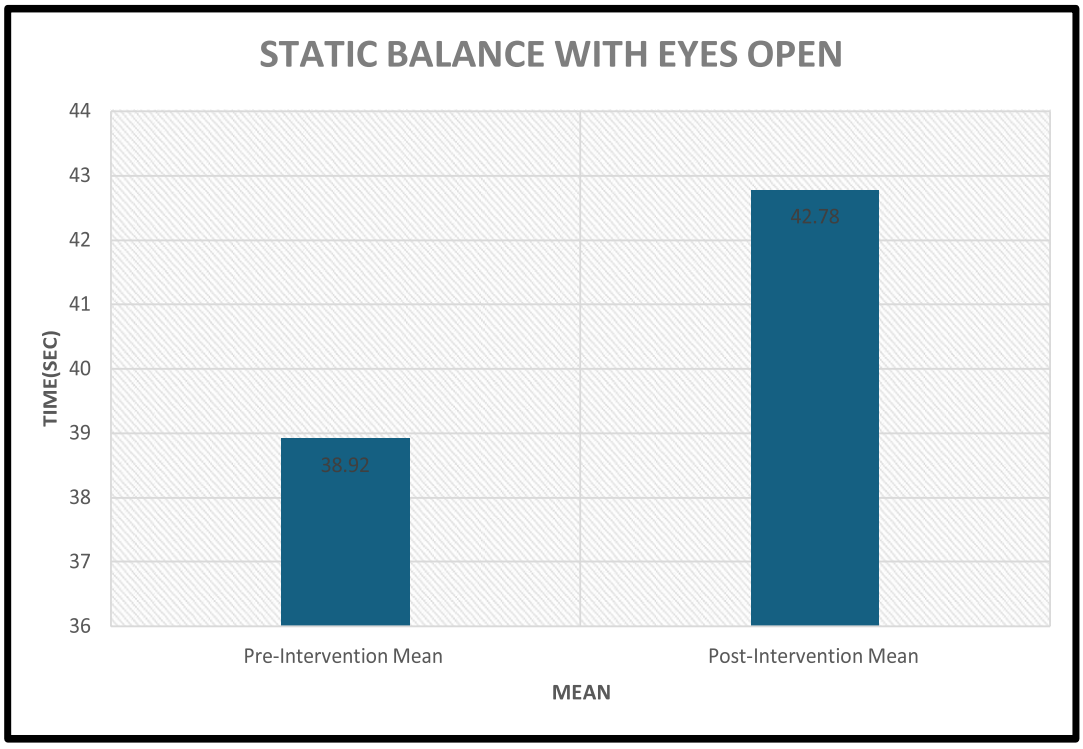
The study included 28 beginner badminton players aged 08-15years old. Gender distribution was 14 males and 14 females. Pre and Post UST, SEBT and Shuttle Run Test scores were calculated. The data collected was statistically analyzed using Microsoft Excel and Graphpad. Paired t-test was used to get the difference between pre and post values.

RESULT

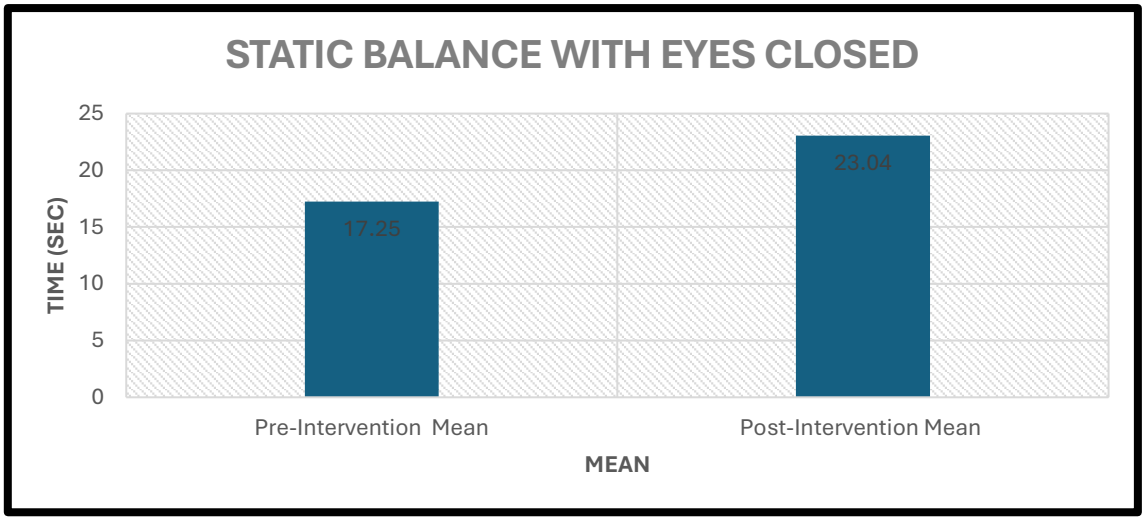
Static balance performance with eyes opened and closed showed a time main effect (p = 0.0158) showing an improvement of around 4 seconds. Dynamic balance showed a significant effect (p = 0.000285) improving distance of reach in all directions.

Outcome Measures	Pre Intervention mean ± SD	Post Intervention mean ± SD	t value	p value	Result
Static Balance Eyes Open	38.007 ± 7.57	42.041 ± 3.47	-6.106	<0.0001	Highly Significant
Static Balance Eyes Closed	14.587 ± 8.50	18.571 ± 10.28	-9.837	<0.0001	Highly Significant
Dynamic Balance	77.984 ± 1.96	79.862 ± 1.98	-16.94	<0.0001	Highly Significant
Footwork Shuttle Run	111.46 ± 16.23	99.35 ± 13.97	11.85	<0.0001	Highly Significant

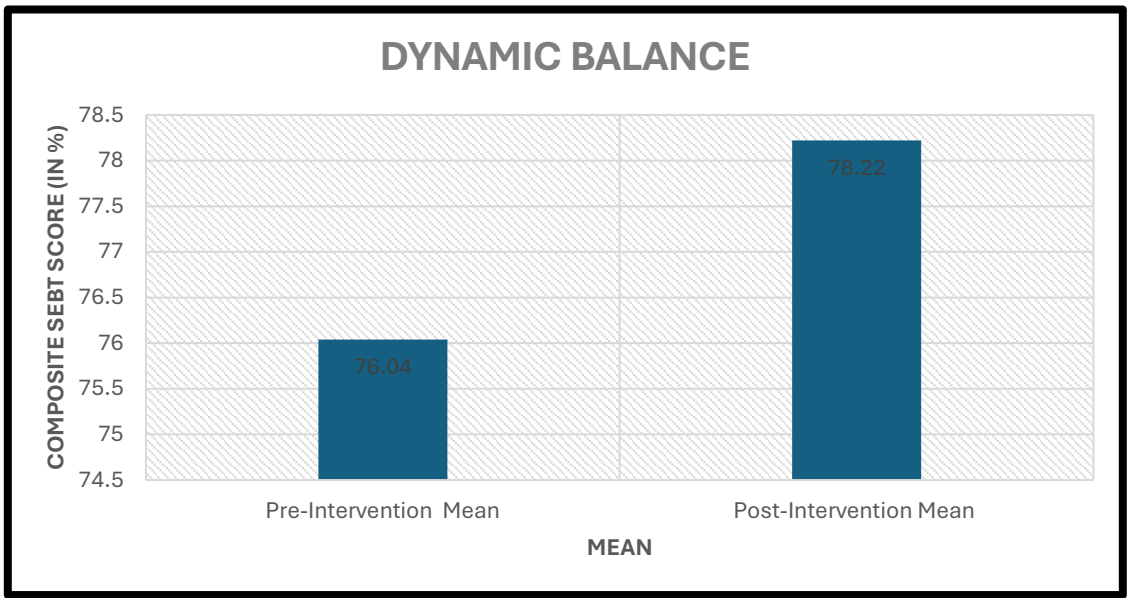
Table 1 Statistical analysis.



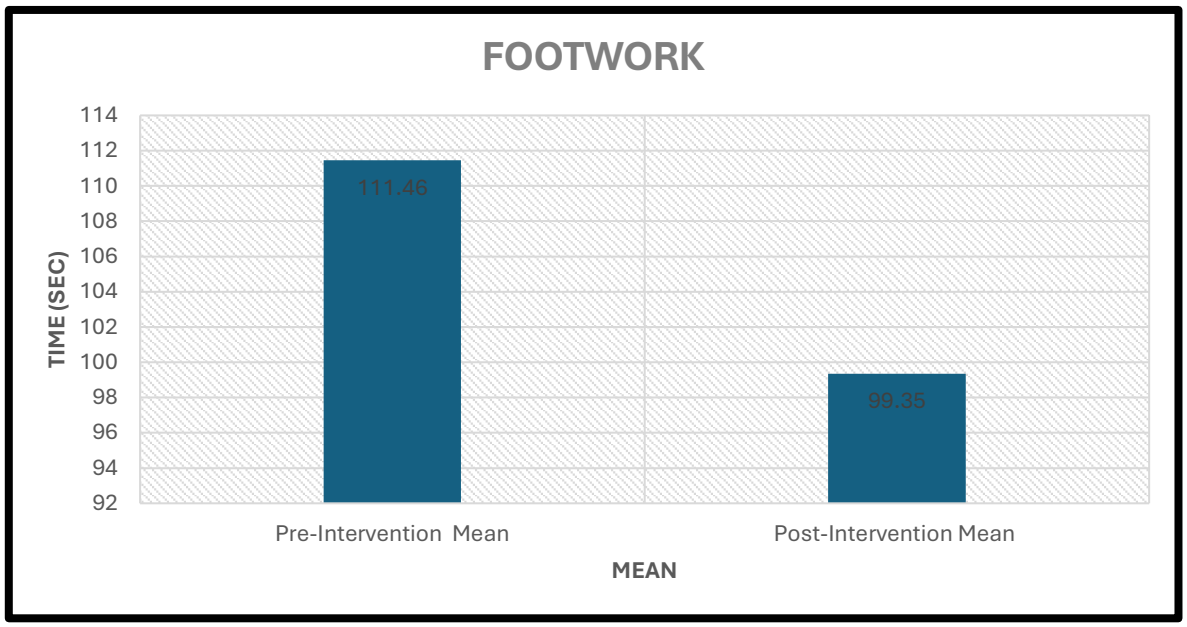
Graph 1 Static Balance with eyes open.



Graph 2 Static Balance with eyes closed.



Graph 3 Dynamic Balance



Graph 4 Footwork

DISCUSSION

In this study, we investigated the effectiveness of a Virtual Reality Based Training program on improving static and dynamic balance, and sport-specific footwork performance of beginner badminton players. We observed significant improvements in static balance with eyes opened and eyes closed and improvement in dynamic balance, we also observed improvement in footwork performance of players at the end of 6 weeks virtual reality-based training. Multiple studies implicate poor balance skills in sport injuries.[10] Previous studies report that lower limb is the most susceptible area for badminton-related injuries,[11-13] according to some studies, accounting to 40% of the injuries in badminton players.[14] It has been shown that balance training can be used prophylactically or after acute ankle sprain to reduce the risk of future ankle sprain.[15] Therefore, apart from enhancing sporting performance, balance training in badminton also improves the safety of the game. Diana Bzdúšková1, et al. stated that exposure to height in VR reliably evokes a realistic experience accompanied by psychological distress, physiological stress response and changes in postural stability. The study revealed a strong association between the measures of balance control and the markers of distress and autonomic arousal, confirming that postural adaptations are an integral part of the protective reaction to the threat of height. The efficacy of height exposure using VR is reflected by the extent to which participants feel immersed and present in the virtual scenery. All participants in our study confirmed they had experienced realistic immersion in the VR environments with high level of involvement and interface quality. Exposure to virtual height evoked a significant distress and sympathetic arousal.[16]

Wen-Chieh Yang, et al. stated, the effects of our VR balance training on balance might be attributable to several factors. First, VR provided ample visual feedback, which patients heavily relied on during skill learning. Our VR balance training system enabled the participants to visualize the shift of body weight, thus facilitating the learning of weight shift control. Second, the VR balance training system provided varied practice to enhance attention focus. In terms of the learning mechanisms, knowledge of performance (KP) is the information about the pattern and quality of an action, whereas knowledge of results (KR) is the information about the outcome of an action with regard to the goal.[17] In VR balance training, the feedback included both KP and KR.[18] For example, in the VR game Height Phobia, KP included the path on which player had to walk on, and KR included the risk of fall from the path if gone away from the path.

Footwork performance is characterized by the ability to accelerate or decelerate and change directions on the court for accurate shots and better performance using different stepping strategies, lunge strategies. Lunges account for approximately 15% of all movements in the badminton court. The players should competently perform lunges in longitudinal, diagonal and transversal directions during a match.

Lam, et al. reported that elite badminton players demonstrate good lunge performance with more aggressive knee and ankle strategy, and this correlates with their chances of winning the game. Kinematic and kinetic analysis revealed that badminton lunges subject the hip and ankle joints to high torques. Maintaining a good balance and a posture counteract these forces during a lunge and prepare the player for the next shot. In addition to lunges, rear court movements in badminton also require the player to have highly developed balance. The ability to maintain dynamic balance has been directly linked to better control of jumping and running to smash, and making the lunges.[19] Many studies suggest that balance is a vital aspect of the footwork performance to move across the court faster.

Kavinda T. Malwanage, et al. reported increase in performance of sports specific footwork after inclusion of balance training

in competitive badminton players aged 13-15years.

Limitation and Future Direction:
It was not possible to connect the VR Headset to an external screen to give us the feedback of what players are able to see inside the VR Headset. Hence, to monitor the players progress in the game we had to rely on players' feedback. Future studies can also examine whether VRBT enhances performance among intermediate badminton players and adult competitive badminton players. Future studies can also examine effectiveness of VRBT on badminton players with lower limb injuries with decreased balance.

CONCLUSION

We observed inclusion of 20 minutes of VRBT with traditional badminton practice improves static and dynamic balance along with footwork in beginner badminton players, after 6 weeks of training. Thus, the coaches and physical trainers can incorporate a VRBT program to improve the balance and footwork of the beginner badminton players to improve players overall performance and achieve intermediate level quickly.

Declaration by Authors

Ethical Approval: Approved
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Conflict of Interest: The authors declare no conflict of interest.

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