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Original Article

VIRTUAL REALITY ENVIRONMENT TRAINING EFFECT ON DYNAMIC AND STATIC STABILITY AMONG ATHLETES FROM RANDOM INTERMITTENT DYNAMIC TYPE SPORTS

EFEITO DO TREINAMENTO DO AMBIENTE DE REALIDADE VIRTUAL NA ESTABILIDADE DINÂMICA ENTRE ATLETAS DE ESPORTES DO TIPO DINÂMICO ALEATÓRIO E INTERMITENTE

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RESUMO

Este estudo tem como objetivo investigar o efeito colateral de um treinamento em ambiente de realidade virtual de seis semanas na estabilidade postural dinâmica e estática em atletas que participam de esportes do tipo dinâmico intermitente aleatório. Os desenhos de estudo pré-teste e pós-teste foram escolhidos para conduzir este estudo. Vinte e quatro atletas do sexo masculino foram selecionados para o estudo. Os participantes participaram de um programa de treinamento em ambiente de realidade virtual de seis semanas, três vezes por semana, durante uma sessão de quarenta e cinco minutos. O ambiente de realidade virtual foi criado usando o sistema de realidade virtual integrado da CAREN com o aplicativo D-flow da Motek. A estabilidade postural foi avaliada por meio de um estadiômetro. As avaliações foram realizadas antes e após seis semanas de treinamento. Um teste t de amostra emparelhada foi usado para determinar as diferenças entre as medidas de resultados pré e pós-teste. A melhoria pode ser vista como um efeito da intervenção de treinamento em ambiente de realidade virtual. Diferenças estatisticamente significativas foram observadas entre o pré e pós-teste para estabilidade postural anteroposterior e mediolateral dinâmica e estática em 20 e 40 níveis de dificuldade. O treinamento em ambiente de realidade virtual ajuda a melhorar o desempenho, avaliando e otimizando a carga de treinamento no processo de melhoria do desempenho de atletas que participam de esportes do tipo dinâmico intermitente aleatório.

Palavras-chave: Equilíbrio postural, Realidade virtual, Esportes, Desempenho atlético, Estabilidade

ABSTRACT

This study aims to investigate the aftereffect of a six-week virtual reality environment training on dynamic and static postural stability in athletes participating in random intermittent dynamic type sports. The pretest and posttest study designs were chosen to conduct this study. Twenty-four male athletes were selected for the study. Participants participated in a six-week virtual reality environment training program three times a week for a session of forty-five minutes. The virtual reality environment was created using CAREN's integrated virtual reality system with Motek's D-flow application. The postural stability was assessed using a stadiometer. Assessments were performed before and after six weeks of training. A paired sample t-test was used to determine differences between pretest and posttest outcome measures. The improvement can be seen as an effect of virtual reality environment training intervention. Statistically significant differences were observed between pretest and posttest for dynamic and static anteroposterior and mediolateral postural stability at 20 and 40 levels of difficulty. The virtual reality environment training helps to improve performance by assessing and optimizing the training load in the process of improving the performance of athletes participating in random intermittent dynamic type sports.

Keywords: Postural balance, Virtual reality, Sports, Athletic performance, Stability.

Introduction

Random intermittent dynamic type sports are as football, hockey, basketball, volleyball, handball, and so on that involved intermittent dynamic activities[1]. In these sports, skilful movement activity patterns are chosen randomly and performed at varying intensities throughout the game. Strength, agility, speed, and other complex physical fitness abilities are essential components in these types of sports.

Postural stability is the most desirable quality in random intermittent dynamic sports for a successful performance because athletes constantly shift their body weight from one extremity to another. Sudden running, jumps, stops, direction changes, dodges, and many more movements need postural stability. Postural stability is a complex activity that affects proprioceptive stimuli originating from visual, vestibular, and somatosensory mechanoreceptors, processing information to the central nervous system and causing appropriate motor response[2–4]. Static and dynamic posture stability has been proven to be an important factor in sports practice, as deficiencies in this ability have been associated with the risk of injuries[5]. Athletes must maintain a certain level of stability and balance (re-acceleration) when transitioning from a dynamic state (deceleration) to a static state (stop to change direction) in sprint motions. During these specialized sports motions, dynamic stability helps maintain a steady centre of gravity[6]. Dynamic postural stability involves movements of the centre of gravity and the base of support.

In contrast, the centre of gravity is never kept within the base of support during the single-extremity support period[7]. Unilateral stability and dynamic neuromuscular control are necessary for sports. In sports, dysfunctional unilateral stability has been identified as a risk for injury. This factor has promoted preventive training programs to improve postural stability that has proved efficient[8,9]. Postural stability can be improved by utilizing different types and specific stability training programs[10].

Balancing exercises, strength training, core stability training, neuromuscular training on a balance board, and manometry training have been investigated in previous research. Virtual reality-based training is a new technology that strongly emphasizes the visual environment. This training replicates a person's interaction with a real environment and provides the same experience of being in a real situation[11]. Virtual reality is an innovative technology-based approach for rehabilitating sports persons with injuries and poor stability and posture control. Furthermore, virtual reality exercises reduce the need for these sportspersons to travel to associated clinics and give rehabilitation, mobility, and functional activities[2,3,12]. Virtual Reality technology is being used to take advantage of its potential as a therapeutic intervention to restore coordinated movement patterns. Virtual reality training can improve balance and motor performance by activating the cerebral cortex and enhancing it[3]. This technology provides the most appropriate individual kinesthetic learning pattern. Similar to computer games, virtual reality exercises are important in performance improvements[13].

Athletes undergo balance training in a clinical setting to improve performance and prevent deterioration in dynamic stability. Investigation of dynamic and static stability after virtual reality training is a key step toward clarifying the mechanisms by how much training might be helpful. Thus, the current study evaluates the aftereffect of the virtual reality environment training on dynamic and static postural stability in random intermittent dynamic type sports athletes.

Methods

Design:

A pretest and posttest study design was chosen to meet the study's objective. This research was carried out in line with the Principles of Helsinki Declaration. The Deanship of Scientific Research granted their permission. All participants were given their informed consent.

Setting:

This study was conducted in the laboratory of the Physical Therapy Department, College of Applied Medical Sciences, Imam Abdulrahman bin Faisal University, Dammam, Saudi Arabia.

Sample Size calculation:

A power analysis was determine using http://sample size.net/correlation-sample size/ to calculate sample size. The calculations used data from a previous study[14] that studied the correlation between Berg balance scale scores and time-up-and-go in a randomized control trial.

The following values were used to calculate the sample size in the study: correlation coefficient of 0.85, significant level at 0.05, and statistical power of 0.8. The calculation gave a sample size of 24 participants. There was no dropout of any participant~~s~~ during the intervention-training program.

Participants:

Only male athletes competing nationally participated in this study. Participants were randomly recruited from different sports clubs in the eastern province. There were nine participants from soccer, eight from handball, four from volleyball, and three from the basketball team. Participants with any musculoskeletal, neurological, or systematic disease and medication that may impact the test or intervention were not allowed to participate.

Anthropometric characteristics:

Table-1 Participants' anthropometric characteristics

	N	Minimum	Maximum	Mean	
	Statistic	**Statistic**	**Statistic**	**Statistic**	**Std. Error**
Age	24	21.00	33.00	23.072	1.379
Height	24	167.00	180.00	174.72	1.338
Weight	24	62.00	94.00	72.73	3.445
BMI	24	18.73	25.07	22.86	0.963

Source: Authors

Table-1 show that the mean age, height, weight, and BMI of the participants were 24.08±4.78 years, 171.91±4.74 cm, 73.83±11.62 kg, and 22.94±8.74 kg/m2, respectively.

Measuring Tools:

Stadiometer: A postural stability test was performed before and after the six-week training session. A bipedal and single leg (Left or Right) test was used to determine the postural stability index using a stabilometer Prokin 252 (TecnoBody, Italy). The test was conducted with eyes open at 20 levels (More Stable) and 40 levels (Less Stable) of stability, with a 30-second rest period between each trial while sitting in a resting chair.

Training Tools:

Virtual Reality System: The Computer Assisted Rehabilitation Environment (CAREN) system (Motek Medical BV, Amsterdam, The Netherlands) was used with a D-flow program for virtual reality training.

Outcome measure:

Postural stability was measured based on the centre of pressure (COP) trajectories. The selected parameters were anteroposterior and mediolateral dynamic and static postural stability.

Procedure

Participants were asked to read the entire research protocol and methodology and sign the consent form before starting the test. Their demographic measures were obtained once they agreed. The virtual reality environment training (CRANE) sessions were held three times per week for six weeks, each lasting 45 minutes. The session includes many immersive applications (Endless Road, Forest Road, Boat Sailing, Mountain Patrol) where participants balance on a moving treadmill and simultaneously walk while performing various physical or cognitive tasks. A team of researchers oversaw each training session. All participants were assessed for postural stability before and after completing six weeks of training sessions.

Before the actual test, the participants were advised to do a 20-minute warmup activity followed by stretching exercises. To familiarize themselves with the device's operation, participants can perform a two-minute trial on the stabilometer. The equilibrium management test was selected to measure the stability index, and Prokin (version 4.8.7) was utilized to conduct the test.

The difficulty level of the stabilometer platform's pressure was adjusted to level 20 (out of 40). The body sensor was connected to the participant's chest, and the participant stood on the platform with both legs and one leg with eyes open. The test was performed according to the company's instructions for open eyes.

Statistical analysis:

The Shapiro-Wilk test was used to determine the normal distribution of data. The postural stability index data were computed as mean, standard deviation, and standard error. The main effect of the virtual reality environment training intervention on assessing the postural stability index for the pretest and posttest was determined using a paired sample t-test. The α (two-tailed) level was set at 0.05 level. The IBM SPSS v-21 was used for data analysis.

Results

Table-2. Dynamic anteroposterior postural stability differences between pretest and posttest at the difficulty levels 20 and 40

	Foot	Test	Mean (SD)	95% CI of the Difference Lower-Upper limit	t	Sig. (2-tailed)
LEVEL 20	BIPEDAL	Pre	0.41 (0.07)	0.129-0.166	16.382	0.000
		Post	0.26 (0.03)	0.292-0.371	17.306	0.000
	LEFT	Pre	0.71 (0.16)	0.209-0.275	15.200	0.000
		Post	0.38 (0.08)	0.057-0.074	16.577	0.000
	RIGHT	Pre	0.59 (0.13)	0.207-0.273	14.828	0.000
		Post	0.35 (0.06)	0.087-0.155	7.360	0.000
LEVEL 40	BIPEDAL	Pre	0.18 (0.03)	0.129-0.166	16.382	0.000
		Post	0.12 (0.01)	0.292-0.371	17.306	0.000
	LEFT	Pre	0.47 (0.13)	0.209-0.275	15.200	0.000
		Post	0.23 (0.05)	0.057-0.074	16.577	0.000
	RIGHT	Pre	0.29 (0.10)	0.207-0.273	14.828	0.000
		Post	0.17 (0.02)	0.087-0.155	7.360	0.000

Note: SD=Standard Deviation, CI=Class Interval, Significant level set at 0.05 level.
Source: authors

The table-2 shows the pretest and posttest comparative statistics of the dynamic anteroposterior postural stability for the bipedal, left, and right legs. Results revealed significant differences between pre and posttest for dynamic anteroposterior postural stability to bipedal, left, and right legs at difficulty levels 20 and 40.

Table-3. Dynamic mediolateral postural stability differences between pretest and posttest at the difficulty levels 20 and 40

	Foot	Test	Mean (SD)	95% CI of the Difference Lower-Upper limit	t	Sig. (2-tailed)
LEVEL 20	BIPEDAL	Pre	0.59 (0.09)	0.231-0.258	37.043	0.000
		Post	0.34 (0.06)	0.257-0.279	51.749	0.000
	LEFT	Pre	0.73 (0.10)	0.228-0.273	23.118	0.000
		Post	0.47 (0.09)	0.104-0.126	21.360	0.000
	RIGHT	Pre	0.67 (0.11)	0.118-0.156	15.067	0.000
		Post	0.42 (0.08)	0.128-0.165	16.366	0.000
LEVEL 40	BIPEDAL	Pre	0.29 (0.05)	0.231-0.258	37.043	0.000
		Post	0.18 (0.03)	0.257-0.279	51.749	0.000
	LEFT	Pre	0.42 (0.07)	0.228-0.273	23.118	0.000
		Post	0.29 (0.04)	0.104-0.126	21.360	0.000
	RIGHT	Pre	0.37 (0.07)	0.118-0.156	15.067	0.000
		Post	0.22 (0.03)	0.128-0.165	16.366	0.000

Note: SD=Standard Deviation, CI=Class Interval, Significant level set at 0.05 level
Source: Author

The Table-3 shows the pretest and posttest comparative statistics of the dynamic mediolateral postural stability for the bipedal, left, and right legs. Results revealed significant differences between pre and posttest for dynamic mediolateral postural stability to bipedal, left, and right legs at difficulty levels 20 and 40.

Table-4 Static anteroposterior postural stability differences between pretest and posttest at the difficulty levels 20 and 40

	Foot	Test	Mean (SD)	95% CI of the Difference Lower-Upper limit	t	Sig. (2-tailed)
LEVEL 20	BIPEDAL	Pre	0.14 (0.03)	0.053-0.063	24.070	0.000
		Post	0.08 (0.02)	0.068-0.101	10.778	0.000
	LEFT	Pre	0.18 (0.05)	0.041-0.055	13.460	0.000
		Post	0.10 (0.02)	0.031-0.046	10.241	0.000
	RIGHT	Pre	0.13 (0.03)	0.083-0.122	10.813	0.000
		Post	0.08 (0.01)	0.055-0.070	16.961	0.000
LEVEL 40	BIPEDAL	Pre	0.11 (0.03)	0.053-0.063	24.070	0.000
		Post	0.07 (0.01)	0.068-0.101	10.778	0.000
	LEFT	Pre	0.19 (0.06)	0.041-0.055	13.460	0.000
		Post	0.09 (0.01)	0.031-0.046	10.241	0.000
	RIGHT	Pre	0.15 (0.03)	0.083-0.122	10.813	0.000
		Post	0.09 (0.01)	0.055-0.070	16.961	0.000

Note: SD=Standard Deviation, CI=Class Interval, Significant level set at 0.05 level
Source: Authors

The Table-4 shows the pretest and posttest comparative statistics of the static anteroposterior postural stability for the bipedal, left, and right legs. Results revealed significant differences between pre and posttest for static anteroposterior postural stability to bipedal, left, and right legs at difficulty levels 20 and 40.

Table-5 Static mediolateral postural stability differences between pretest and posttest at the difficulty levels 20 and 40

	Foot	Test	Mean (SD)	95% CI of the Difference Lower-Upper limit	t	Sig. (2-tailed)
LEVEL 20	BIPEDAL	Pre	0.22 (0.06)	0.100-0.129	16.570	0.000
		Post	0.11 (0.03)	0.113-0.168	10.469	0.000
	LEFT	Pre	0.25 (0.08)	0.165-0.223	13.828	0.000
		Post	0.11 (0.02)	0.075-0.117	9.334	0.000
	RIGHT	Pre	0.32 (0.10)	0.159-0.255	8.923	0.000
		Post	0.13 (0.03)	0.178-0.237	14.629	0.000
LEVEL 40	BIPEDAL	Pre	0.18 (0.07)	0.100-0.129	16.570	0.000
		Post	0.08 (0.02)	0.113-0.168	10.469	0.000
	LEFT	Pre	0.32 (0.14)	0.165-0.223	13.828	0.000
		Post	0.12 (0.03)	0.075-0.117	9.334	0.000
	RIGHT	Pre	0.34 (0.11)	0.159-0.255	8.923	0.000
		Post	0.13 (0.04)	0.178-0.237	14.629	0.000

Note: SD=Standard Deviation, CI=Class Interval, Significant level set at 0.05 level
Source: Authors

The table-5 shows the pretest and posttest comparative statistics of the static mediolateral postural stability for the bipedal, left, and right legs. Results revealed significant differences between pre and posttest for static mediolateral postural stability to bipedal, left, and right legs at difficulty levels 20 and 40.

Discussion

This study examined the effects of a six-week virtual reality environment training intervention on postural stability in random intermittent dynamic sports athletes. The main finding showed improved dynamic stability index performance as an effect of virtual reality environment training intervention. However, this effect was statistically significant for the dynamic and static postural stability between pretest and posttest for bipedal, left, and right legs at 20 and 40 levels of difficulty.

These findings are consistent with the previous study conducted by Yang et al. with twenty-three participants who underwent twelve 50-minute training sessions over six weeks. The experimental group (n = 11) received training from a custom-made virtual reality balance training system, while the control group (n = 12) received training from a licensed physical therapist. The effects of home-based virtual reality balance training and conventional home balance training were not found to differ significantly. The two training methods improved participants' balance, walking, and overall quality of life[15]. Whereas the effects of virtual reality-based exercise on obstacle crossing performance and dynamic balance were investigated by Liao et al. Thirty-six people were randomly assigned to one of three groups. Virtual reality-based training or traditional exercise were given to one exercise group. The control group did not receive a structural exercise program. The finding of this study revealed that the virtual reality group improved their obstacle crossing velocity and dynamic balance more than the control group[16]. Similar findings were reported in a table tennis research conducted in 2019.

Before a second table tennis examination, participants were given a table tennis assessment and then randomized to take either six table tennis training sessions or no training. The virtual reality training group exhibited significantly higher improvements in real-world table tennis performance than the control group. Similar results have also been reported for darts[17].

A few research studies have been conducted in this field, indicating that computer technology has potential. In a 2009 research, 32 university students were randomly assigned to either bowling training on a Nintendo Wii or no training before taking a bowling ability test. The researchers discovered that individuals who practised bowling on the Wii had better bowling performance[18]. Faigenbaum et al. found a specific improvement in postural stability after six weeks, five times per week, ten-minute rope balancing training provided[19]. Foweather et al. revealed that a nine-week after-school sports activity program for students aged 8–9 years significantly improved their static balance[20]. Grancher et al. indicated that traditional balance-training programs three times per week for four weeks showed only a small to moderate effect on postural stability[21]. Deveau et al. informed that specific training alters the brain to better respond to real-life situations[22].

Aftereffect of virtual reality environment training investigated in the current study. There were several factors attributed to stability, and it is a multifaceted issue such as strength, sensation of depth, response time and movement[23]. This statement is supported by the fact that equilibrium is multifaceted. It appears reasonable that virtual reality environment training might enhance stability by simultaneously impacting many key elements that determine stability, such as strength, proprioception, response speed, and movement coordination[24].

An exercise program that strengthens balance, improves postural oscillation, and increases proprioception should be designed to avoid injury. Furthermore, this workout regimen allows the athlete to return to sports much safer and speedier. Athletes from the sports of basketball, volleyball, football, and handball were chosen for this study. These disciplines include most non-impact lower extremities injuries, such as zigzag movements, shearing manoeuvres, and jumping and landing mechanics[6]. Therefore, the research training protocol to improve balance performance requires jumping and landing on one or two legs, zigzag and shearing motions in the anterior and sagittal planes without losing balance and agility[25]. Virtual reality environment training for balance can improve posture stability, response time, balance, and gait function by introducing more rational visual and perceptual inputs[26]. As a result, Virtual reality environment training with balance games can be an effective and beneficial tool for training athletes with poor stability[27].

There are several limitations to this study. Firstly, the study was confined to male athletes only, limiting the data's generalizability. Second, the virtual reality system has been limited in use by the researcher. Thirdly, to generalize the study findings, a larger and more diverse population, including female athletes and different sports individuals, should be studied using other balancing tests. Furthermore, more research is needed to establish the impact of the virtual reality environment training intervention.

Conclusion

In summary, in this study we find there were higher significant improvements in static and dynamic postural stability in all direction as the effect of virtual reality environment training intervention. Such training strategies can be utilized by sports scientists, coaches, and physical therapists to improve the performance. More research are needed with a larger sample size, varied study designs, different training protocols, and diverse sports population to enhance the performance by increase the postural stability and prevent the injuries.

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