CLINICAL AND PHYSICAL EFFICIENCY OF VIRTUAL REALITY GAMES IN SOCCER PLAYERS WITH LOW BACK PAIN

EFICIÊNCIA CLÍNICA E FÍSICA DE JOGOS DE REALIDADE VIRTUAL EM JOGADORES DE FUTEBOL COM DOR LOMBAR

EFICIENCIA DE LOS JUEGOS DE REALIDAD VIRTUAL EN JUGADORES DE FUTBOL CON DOLOR DE ESPALDA BAJA

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Gopal Nambi[1]
(Physiotherapist)
Walid Kamal Abdelbasset[1,2]
(Physiotherapist)
Shereen H. Elsayed[3,4]
(Physiotherapist)
Anju Verma Msc[1]
(Physiotherapist)
Julie Saji George Msc[1]
(Physiotherapist)
Ayman K. Saleh MD[5,6]
(Orthopedic Surgeon)

1. Prince Sattam bin Abdulaziz University, College of Applied Medical Sciences, Department of Physical Therapy and Health Rehabilitation, Alkharj, Saudi Arabia.
2. Cairo University, Kasr Al-Aini Hospital, Department of Physical Therapy, Giza, Egypt.
3. Princess Nourah bint Abdulrahman University, Faculty of Health and Rehabilitation Sciences, Department of Rehabilitation Sciences, Riyadh, Saudi Arabia.
4. Cairo University, Department of Physical Therapy for Cardiovascular/Respiratory Disorders and Geriatrics, Faculty of Physical Therapy, Giza, Egypt.
5. Prince Sattam Bin Abdulaziz University, College of Medicine, Department of Surgery, Al-Kharj, Saudi Arabia.
6. Al-Azhar University, Faculty of Medicine for Girls, Department of Orthopedics, Cairo, Egypt.

Correspondence
Gopal Nambi
Dept of Physical Therapy and Health Rehabilitation, Prince Sattam Bin Abdulaziz University, Al-Kharj, Saudi Arabia.
physio_gopal@rediffmail.com

ABSTRACT

Introduction: Virtual reality training (VRT) is an advanced technology that creates virtual games by a computer through specific software. It is a type of rehabilitation training commonly used in balance problems to treat musculoskeletal conditions. Objective: To determine and compare the effects of virtual reality games with those of core stabilization training on physical efficiency in soccer players with chronic low back pain. Methods: A randomized, double-blinded, controlled study was conducted on 60 LBP participants at a university hospital. The first group (n=20) received virtual reality (VR) training; the second group (n=20) received core stabilization (CS) training; and the third group (n=20) received conventional training exercises for four weeks. Scores of clinical and sports performance were measured at baseline, and after 4 weeks, 8 weeks and 6 months. Results: The baseline demographic and clinical characters did not show any significant differences (p>0.05) in the statistical analysis, which shows a homogenous population. Four weeks following the training, the VR training group showed more significant changes in clinical scores than the CS training and control groups (p≤0.001). The scores for sports performance also showed more significant improvement in the VR training group than in the other two groups (p≤0.001). The same improved clinical and sports performance changes were seen at 8 weeks and 6 months of follow-up in the VR training group, when compared to the other two groups (p≤0.001). Conclusion: This study suggests that training through virtual reality games results in long-term improvement in clinical and sports performance compared to other forms of training in soccer players with chronic low back pain. ***Level of evidence I b; Therapeutic studies – Investigation of treatment results.***

Keywords: Virtual games; Core stabilization; Games; Soccer; Low back pain.

RESUMO

Introdução: O treinamento com realidade virtual (TRV) é uma tecnologia avançada que cria jogos virtuais para computador por meio de software específico. É um tipo de treinamento de reabilitação comumente usado em problemas de equilíbrio no tratamento de doenças musculoesqueléticas. Objetivo: Determinar e comparar os efeitos dos jogos de realidade virtual com o treinamento de estabilização central na eficiência física de jogadores de futebol com dor lombar crônica. Métodos: Estudo randomizado, duplo-cego e controlado realizado com 60 participantes com lombalgia em um hospital universitário. O primeiro grupo (n = 20) recebeu treinamento de realidade virtual (RV), o segundo grupo (n = 20) recebeu treinamento de estabilização central (EC) e o terceiro grupo (n = 20) recebeu exercícios de treinamento convencional por quatro semanas. Os escores de desempenho clínico e esportivo foram medidos no início do estudo e depois de 4 semanas, 8 semanas e 6 meses. Resultados: As características demográficas e clínicas basais não mostraram diferença significativa (p > 0,05) na análise estatística, o que indica população homogênea. Quatro semanas depois do treinamento, o grupo RV mostrou mudanças mais significativas nos escores clínicos do que os grupos EC e controle (p ≤ 0,001). Os escores de desempenho esportivo também mostraram melhora significativa no grupo RV do que nos outros dois grupos (p ≤ 0,001). As mesmas mudanças benéficas de desempenho clínico e esportivo foram observadas em 8 semanas e 6 meses de acompanhamento no grupo RV em comparação com os outros dois grupos (p ≤ 0,001). Conclusão: Este estudo sugere que o treinamento com jogos de realidade virtual resulta em melhora do desempenho clínico e esportivo a longo prazo do que outras formas de treinamento em jogadores de futebol com dor lombar crônica. ***Nível de evidência Ib; Estudos terapêuticos, Investigação dos resultados de tratamentos.***

Descritores: *Jogos virtuais; Estabilização do núcleo; Jogos; Futebol; Dor lombar.*

RESUMEN

Introducción: El entrenamiento de realidad virtual (VRT) es una tecnología avanzada, que crea juegos virtuales por computadora a través de un software específico. Es un tipo de entrenamiento de rehabilitación que se usa comúnmente en problemas de equilibrio para tratar afecciones musculoesqueléticas. Objetivo: Encontrar y comparar los efectos de los juegos de realidad virtual sobre el entrenamiento de estabilización central sobre la eficiencia física en jugadores de fútbol con dolor lumbar crónico. Métodos: Se realizó un estudio controlado, aleatorizado, doble ciego

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en 60 participantes con dolor lumbar en un hospital universitario. El primer grupo (n = 20) recibió entrenamiento de realidad virtual (VR), el segundo grupo (n = 20) recibió entrenamiento de estabilización central (CS) y el tercer grupo (n = 20) recibió ejercicios de entrenamiento convencionales durante cuatro semanas. Los puntajes de rendimiento clínico y deportivo se midieron al inicio del estudio, después de 4 semanas, 8 semanas y 6 meses. Resultados: Los caracteres demográficos y clínicos basales no mostraron ninguna diferencia significativa (p. 0,05) en el análisis estadístico lo que indica una población homogénea. Cuatro semanas después del entrenamiento, el grupo de entrenamiento de RV mostró cambios más significativos en las puntuaciones clínicas que los de entrenamiento de CS y los grupos de control (p≤0,001). Las puntuaciones de rendimiento deportivo también mostraron una mejora significativa en el grupo de entrenamiento de RV comparadas con los otros dos grupos (p≤0,001). Hubo los mismos cambios clínicos y de rendimiento deportivo a las 8 semanas y 6 meses de seguimiento en el grupo de entrenamiento de RV y en los otros dos grupos (p≤0,001).Conclusión: Nuestro estudio sugirió que el entrenamiento a través de juegos de realidad virtual mejoró el rendimiento clínico y deportivo más que otros entrenamientos en jugadores de fútbol con dolor lumbar crónico a largo plazo. ***Nivel de evidencia Ib; Estudios terapéuticos, investigación de los resultados del tratamiento.***

Descriptores: *Juegos virtuales; Estabilizacion central; Juegos; Futbol; Dolor lumbar.*

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INTRODUCTION

The game Soccer is more common in America, also known as football in many parts of the world; which is a high priority team sport for all the age groups. Moreover, increasing number of games and training sessions tends to increase the number of sports injuries. Lower back is the most common site and contributes 47% among these injuries.[1] Low back pain (LBP) is the common problem noted in this sport and it is directly related with the trunk balance.[2] Studies report that, rupture of soft tissues around the back during soccer game have direct impact on trunk balance and its controlling mechanisms.[3] The other factors which may alter the trunk balance are using wrong and bad techniques during the play, poor physical conditioning and abnormal movements in the body.[4,5] Moreover, taking part in any sports without proper training also leads to LBP; which eventually affects the overall sports performance of a player.[6] Therefore, different sports injury preventive and restorative exercise training protocols have been framed to overcome such problems.[7-9] Usually, trained sports therapists and sports coaches provide such training protocols at on and off the ground to the players.[10]

Recently Nambi G et al notices that, advanced training procedures have replaced the traditional procedures and shows favorable results in sports performances.[11] Virtual reality (VR) exercise is a leading advanced exercise procedure, in which the virtual environment is created by computer software. It is a type of training procedure often used for balance disorders in neurological patients but its effect on musculoskeletal condition such as LBP is lacking. The principle of virtual exercise is activating the visual and auditory cues through different virtual games. Moreover, virtual exercise enhances the functioning capacity of the patients through selection of suitable activities within their efficiency.[12,13] It makes the training more fun and decreases the hardships of training during rehabilitation. The mechanism behind VR exercise is that this technology activates the sensory domain through its neuroplastic alterations and neural organizations. These alterations in nervous system activate the muscles for new motor learning process further.[14,15]

Core stabilization (CS) exercise of trunk is another set of exercise applied in the management of LBP. This training commonly uses therapeutic ball to rehabilitate the core muscles of trunk. CS provides an environment to the patient to maintain the balance by controlling the Centre of gravity. The ball increases the active recruitment of trunk muscles and improves the global and local stabilizer of the trunk. Training with therapeutic ball also provides motivation and pleasure to the movements, which enhances the spinal muscle recruitment.[16] Same like VR exercise, CS also activates the nervous system for facilitating the motor unit activity.[17,18] It is also observed that, wide clinical differences have noted between stabilization exercise and traditional exercise in LBP patients.[19,20]

Nevertheless, the insight and judgment of the adequate application of VR and CS exercises and its clinical and physical efficiency in soccer players with LBP is lacking. Hence the objective of this trial was to find and compare the efficiency of virtual exercise over stabilization exercise on clinical and physical efficiency in soccer players with LBP. The extensive and elaborative understanding of these training protocols promotes the sports rehabilitation in a positive way.

METHODS

Study design

This was a prospective, randomized, active parallel controlled trial and sixty (n=60) participants were randomized through computer random table method into virtual reality (VR; n=20) training group, core stabilization (CS; n=20) training group and active control group (Co; n=20). Ethical approval (RHPT/019/045) was obtained from department ethical committee and the study was executed as per the instructions of Helsinki 1975. It was a single center study and executed at Physiotherapy outpatient clinic, Prince Sattam bin Abdulaziz University, Al Kharj, Saudi Arabia. Participants diagnosed with chronic LBP by an orthopedist were referred from university hospital. Therapist at the outpatient clinic assessed all the referred participants for including in the study.

Participants

Those who read and consent to take part in the trial were permitted for next level of assessment. For this, the participants had to meet certain fixed criteria; Inclusion criteria: male soccer players between 18 and 25 years old, more than three months of pain, pain on the numerical pain rating scale (NPRS) between 4 and 6. Exclusion criteria: another associated injury, associated deformity; systemic disease, waiting for surgery, previous surgery, involvement in another training protocol, and use of medication.

Interventions

The participants in VR group received the respective exercises for the core muscles of trunk with Pro-Kin system PK 252 N Techno body, Italy. The information about this application was instructed through personal education. The participant was asked to sit in the virtual platform which offers challenges to the trunk movement. Firing game was selected in this study and asked him to follow the game instructions. The game was

executed by trunk movements (flexion, extension and lateral flexion) within the limitations of pain. The difficulty level in the game can be altered by increasing or decreasing the various game parameters. The participant can be progressed to the next level once he achieved the current level and the exercises were done for 30 minutes per day.[20]

The CS group performed the core stability training through therapeutic ball (Pro serious, India) for the spinal stabilizers. Different set of exercises were performed on the ball such as; Quadruped arm rise, cat and camel, pelvic tilt, side plank and extension exercises. These exercises were performed for 15 times for 3 sets and they were asked to keep each pose for 15 seconds.[21] The control group received the traditional active balance exercise for the abdominal muscles and back muscles. Self-stretching was done to all the group muscles of lower limb for 30 seconds. All the three groups had undergone the training for 5 times in a week for four weeks. Also all the participants in the three groups had underwent heat modality for twenty minutes and therapeutic ultrasound for five minutes.[22]

Outcome Measures

Pain status: It was assessed with numerical pain rating scale (NPRS), in which there was a line consisted of 10 points starting with 0 to 10. The participant was asked to point the pain perception on the line, where '0' denotes 'no pain' and '10' denotes 'maximum pain'. The score was measured by the number he pointed and it was a good tool to measure pain intensity in LBP.[23]

Quality of life: The quality of life of the participant was rated by physical fitness index. It consists of five items and the participant was instructed to mention his state on the five-point scale. The point one notes 'very poor' and point five indicates 'very well'. Hence the total score obtained between 5 and 25 and the grade of wellness was calculated.[24]

Sprint Performance

Forty-meter sprint: The participant was asked to run with his maximum speed for forty m and the timer measured the time taken to complete the distance in seconds.

Zigzag sprint: The participant was asked to run for 20 m in a zigzag manner with 90^0 directional changes in every 5 m. The total time taken to complete the task was measured in seconds.[25]

Submaximal shuttle running: The participant was instructed to complete 10 m distance for 6 minutes with a velocity of 6 km/hr. Front-back, right-left and perpendicular pressure loading was measured with micro electro mechanical device.[26]

Jump performance

Counter jump (CJ): The participant was asked to jump by keeping hands on the hips without bending hip and knees.

Squat Jump (SJ): The participant was asked to jump by keeping hands on the hips with bending of hip and knees and the distance, strength and speed were scored.[27]

Sample size

The sample size was calculated through a preliminary study, in which the number of samples needed for this study was 54. It was obtained by agreeing 80 percentage study power with 20 percentage difference in pain status (NPRS) and the assumed standard deviation (SD) of two with the alpha level of 5%. Totally 60 participants were included in the study with the consideration of ten percentage of drop out.

Statistical analysis

All the participant's baseline demographic and clinical attributes were recorded to find the sample homogeneity using Smirnov Kolmogorov test. The study measurements were drawn as mean and SD and repeated measures of analysis of variance (ANOVA) test was used to find the difference at varied spells. The difference between the groups was tested by one way ANOVA and the significant level was $p<0.05$.

RESULTS

Participants

This trial excluded six participants with pain intensity more than 6 in NPRS, eight with other associated injuries and two with awaiting spinal surgeries. (Figure 1) Sixty (N=60) eligible participants were selected out of 85, and randomized into three groups. One participant each from VR and CS group did not finish the entire study duration and intention to treat was followed in the data analysis. The baseline demographic and clinical characters were not shown any statistical difference ($p>0.05$) between the groups, which indicates homogenous population (Table 1). The clinical characters were collected to measure the fitness level to involve in such exercise programs.

Pain status and quality of life

The pre score values of pain status (NPRS) and Quality of life (physical fitness index) of VR, CS and control group did not show any statistical difference ($p>0.05$), which indicated sample homogeneity. After

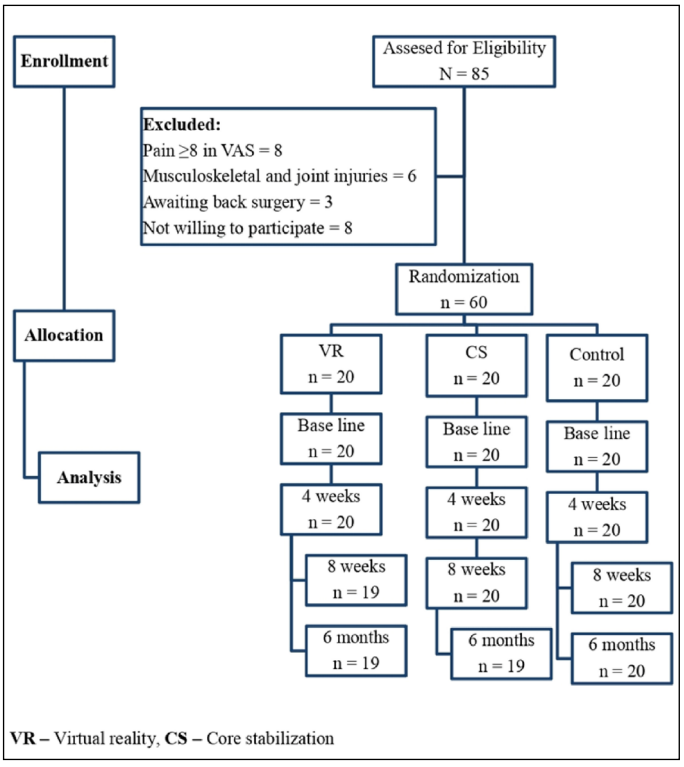

Figure 1. Flow chart showing the study details.

Table 1. Mean and standard deviation of demographic variables of VR, CS and control group.

No	Variable	VR	CS	Control	p-value
1	Age (y)	21.45 ± 1.5	21.39 ± 1.4	20.97 ± 1.5	0.533*
2	Height (m)	1.67 ± 0.15	1.66 ± 0.17	1.68 ± 0.16	0.925*
3	Weight (kg)	68.3 ± 2.5	67.4 ± 2.6	68.9 ± 2.7	0.194*
4	BMI (kg/m^2)	23.8 ± 1.4	23.5 ± 1.5	22.9 ± 1.6	0.164*
5	VO_2peak (mL/kg/min)	38.2 ± 3.7	37.9 ± 3.6	38.4 ± 3.1	0.900*
6	HR (beats/min)	167 ± 5.7	169 ± 5.8	168 ± 5.4	0.536*
7	Years of playing (y)	3.9 ± 1.7	4.1 ± 1.8	3.8 ± 1.5	0.846*
8	Duration of Injury (m)	4.8 ± 0.5	5.2 ± 0.6	4.9 ± 0.5	0.056*

* Non-Significant, VR – Virtual reality, CS – Core stabilization.

four weeks of sports training, the scores of NPRS and physical fitness index in VR, CS and Control group at various intervals showed clinical and statistical difference (p<0.001). Furthermore, intra group analysis through repeated measures of ANOVA (p<0.001) showed substantial improvement in each group in pain status and Quality of life. (Table 2) The Benferroni post hoc test showed more statistical improvement in pain status. (Figure 2) and improvement in quality of life in VR group than CS and control groups.

Sprint performance

The types of sprint such as forty meter sprint, 4 × 5 m sprint and sub maximum shuttle sprint were scored at baseline and at various intervals in all the three groups. The pre scores of all types of sprint activities of VR, CS and control group did not show any statistical difference (p>0.05), which indicated sample homogeneity. After four weeks of different sports training, the sprint scores in VR, CS and Control group at various intervals showed statistical difference (p≤0.001). Furthermore, intra group analysis through repeated measures of ANOVA at various intervals (p≤0.001) showed substantial improvement in all the groups. (Table 2) The Benferroni post hoc test showed more statistical changes in sprint scores (Figure 2) and enhancement in physical efficiency in VR group than CS and control groups.

Table 2. Comparison of pain status, quality of life and sprint performance of VR, CS and control group.

Sr.No	Variable		VR	CS	Control	p-value
1	Pain status	Base line	7.2 ± 0.6	7.3 ± 0.5	7.4 ± 0.5	0.501*
		4 weeks	4.1 ± 0.3	4.9 ± 0.5	6.1 ± 0.5	0.001**
		8 weeks	1.8 ± 0.4	3.2 ± 0.4	5.5 ± 0.3	0.001**
		6 months	1.1 ± 0.3	2.8 ± 0.3	4.5 ± 0.4	0.001**
		p-value	0.001**	0.001**	0.001**	
2	Quality of life	Baseline	8.59 ± 1.4	8.56 ± 1.3	8.43 ± 1.4	0.925*
		4 weeks	13.48 ± 1.3	12.22 ± 1.5	9.98 ± 1.3	0.001**
		8 weeks	18.31 ± 1.8	16.315 ± 1.6	11.22 ± 1.5	0.001**
		6 months	21.32 ± 2.1	18.79 ± 1.3	13.38 ± 1.5	0.001**
		p-value	0.001**	0.001**	0.001**	
3	40 m sprint	Baseline	15.92 ± 1.4	15.23 ± 1.5	15.48 ± 1.4	0.312*
		4 weeks	11.54 ± 0.9	12.89 ± 0.8	13.44 ± 0.9	0.001**
		8 weeks	8.43 ± 0.4	9.82 ± 0.4	11.21 ± 0.6	0.001**
		6 months	4.21 ± 0.2	6.33 ± 0.3	9.89 ± 0.5	0.001**
		p-value	0.001**	0.001**	0.001**	
3	Zigzag sprint (s)	Base line	23.92 ± 1.9	23.12 ± 1.8	23.76 ± 1.6	0.326*
		4 weeks	17.68 ± 0.8	15.12 ± 0.5	19.778 ± 0.6	0.001**
		8 weeks	10.48 ± 0.6	11.38 ± 0.5	16.78 ± 0.5	0.001**
		6 months	7.81 ± 0.3	9.19 ± 0.3	14.26 ± 0.4	0.001**
		p-value	0.001**	0.001**	0.001**	
4	Submaximal shuttle running Front/Back	Base line	8.56 ± 1.8	8.47 ± 1.6	7.97 ± 1.5	0.475*
		4 weeks	19.38 ± 1.5	19.29 ± 1.4	11.83 ± 1.5	0.001**
		8 weeks	26.48 ± 1.8	24.05 ± 1.5	16.28 ± 1.3	0.001**
		6 months	33.69 ± 2.2	29.52 ± 2.3	19.18 ± 1.8	0.001**
		p-value	0.001**	0.001**	0.001**	
	Right/Left	Base line	11.32 ± 2.1	11.21 ± 2.3	10.93 ± 2.2	0.846*
		4 weeks	19.21 ± 2.2	20.17 ± 2.5	13.08 ± 2.3	0.001**
		8 weeks	26.04 ± 2.4	27.58 ± 2.5	16.03 ± 2.4	0.001**
		6 months	34.23 ± 2.6	30.23 ± 2.2	18.06 ± 1.8	0.001**
		p-value	0.001**	0.001**	0.001**	
	Perpendicular	Base line	16.89 ± 2.8	17.23 ± 2.7	17.32 ± 2.5	0.865*
		4 weeks	32.29 ± 3.1	29.12 ± 3.2	22.47 ± 3.1	0.001**
		8 weeks	46.72 ± 3.7	42.05 ± 3.2	27.64 ± 3.0	0.001**
		6 months	62.98 ± 4.2	55.21 ± 3.8	34.12 ± 3.1	0.001**
		p-value	0.001**	0.001**	0.001**	

* Non Significant, ** Significant, VR – Virtual reality, CS – Core stabilization.

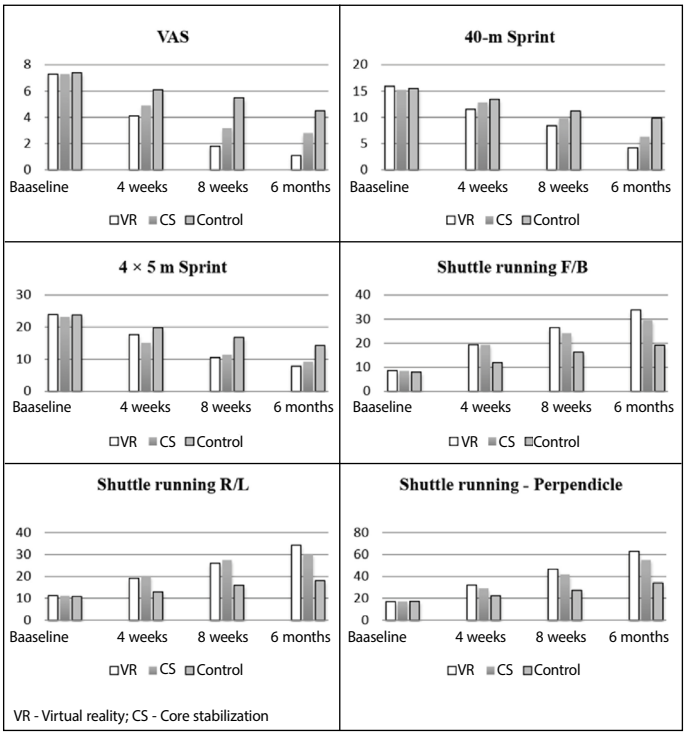

Figure 2. Mean values of pain status, 40 m sprint, 4 × 5 sprint, shuttle running scores in VR, CS and control group.

Jump performance

The CJ and SJ were commonly assessed after sport rehabilitation to find the fitness level of the participants and these variables were assessed at various intervals. The pre scores of counter Jump and squat Jump of VR, CS and control group did not show any statistical improvement (p>0.05), which indicated sample homogeneity. After four weeks of different sports training, the CJ and SJ scores in VR, CS and control group at different intervals showed statistical difference (p≤0.001). Furthermore, intra group analysis through repeated measures of ANOVA at various intervals (p≤0.001) showed substantial improvement in all the groups (Table 3) in CJ and SJ variables. The Benferroni post hoc test showed more statistical changes in CJ and SJ scores (Figure 3) and overall improvement in physical efficiency in VR group than CS and control groups.

DISCUSSION

This study found that virtual reality games reduced the pain status in VR group by changing the inflammatory mechanism than CS and control groups. It was known that higher percentages of inflammatory cytokines were presented in LBP. Virtual games enhanced the energy consumption through wide range of pain free movements, which was comparatively less in the other two groups. This mechanism induced the positive changes in pro-inflammatory cytokines such as CRP, TNF-α and IL-6[28] These exercises also released the anti-inflammatory cytokines such as IL-2 and IL-4; which has tremendous role in pain reduction and it was observed by Gleeson, M et al.[29] Nambi, G et al.[30] noted that virtual training facilitated the sensory system through visual and auditory cues. This stimulation activated the motor system, which in turn improved the properties (strength and power) of focused muscles.

VR games worked under the principle of real-time feedback, which fastened the player to complete the present stage of game and motivates him to quickly go to the next stages of game. This process directly activated and coordinated the core muscles of the trunk, which could improve the physical efficiency[14,31] The different games in the VR changed the external environment of the participant and activated the neuroplasticity of the brain. However, D'hooge R et al.[32] stated that

Table 3. Comparison of **c**ounter movement jump and squat jump of VR, CS and Control group.

Sr.No	Variable		VR	CS	Control	p-value
1	Counter Jump Distance (cm)	Baseline	21.22 ± 1.8	21.38 ± 1.7	21.27 ± 1.7	0.954*
		4 weeks	32.23 ± 2.1	31.34 ± 2.3	23.01 ± 2.1	0.001**
		8 weeks	42.21 ± 2.2	37.04 ± 2.4	25.12 ± 2.5	0.001**
		6 months	47.21 ± 2.4	42.21 ± 2.2	27.32 ± 2.1	0.001**
		p-value	0.001**	0.001**	0.001**	
	Strength (N)	Baseline	918.2 ± 112	912.5 ± 113	920.2 ± 114	0.975*
		4 weeks	1076.8 ± 122	1054.7 ± 121	963.3 ± 117	0.009**
		8 weeks	1238.5 ± 132	1192.3 ± 130	1082.2 ± 128	0.001**
		6 months	1392.7 ± 144	1225.6 ± 132	1136.4 ± 112	0.001**
		p-value	0.001**	0.001**	0.001**	
	Speed ($m.s^{-1}$)	Baseline	0.93 ± 0.03	0.94 ± 0.02	0.93 ± 0.03	0.408*
		4 weeks	1.36 ± 0.02	1.47 ± 0.02	1.09 ± 0.03	0.001**
		8 weeks	2.23 ± 0.03	1.97 ± 0.03	1.85 ± 0.02	0.002**
		6 months	2.92 ± 0.03	2.25 ± 0.03	1.19 ± 0.02	0.001**
		p-value	0.001**	0.001**	0.001**	
2	Squat Jump Distance (cm)	Baseline	17.72 ± 2.6	17.68 ± 2.4	17.92 ± 2.5	0.948*
		4 weeks	26.93 ± 1.8	26.38 ± 1.6	22.38 ± 1.5	0.193*
		8 weeks	38.23 ± 1.9	32.11 ± 1.7	24.56 ± 1.3	0.002**
		6 months	44.02 ± 2.2	39.24 ± 1.9	25.46 ± 1.2	0.001**
		p-value	0.001**	0.001**	0.001**	
	Strength (N)	Baseline	935.21 ± 89	931.642 ± 85	932.57 ± 86	0.990*
		4 weeks	1092.32 ± 101	1092.18 ± 105	976.21 ± 103	0.193*
		8 weeks	1373.83 ± 114	1267.38 ± 106	1053.2 ± 102	0.002**
		6 months	1460.43 ± 126	1326.57 ± 112	1092.4 ± 102	0.001**
		p-value	0.001**	0.001**	0.001**	
	Speed ($m.s^{-1}$)	Baseline	0.69 ± 0.03	0.67 ± 0.02	0.68 ± 0.03	0.073*
		4 weeks	1.38 ± 0.02	1.05 ± 0.02	0.92 ± 0.02	0.193*
		8 weeks	1.92 ± 0.02	1.32 ± 0.02	1.11 ± 0.02	0.002**
		6 months	2.53 ± 0.03	2.03 ± 0.03	1.23 ± 0.02	0.001**
		p-value	0.001**	0.001**	0.001**	

* Non Significant, ** Significant, VR – Virtual reality, CS – Core stabilization.

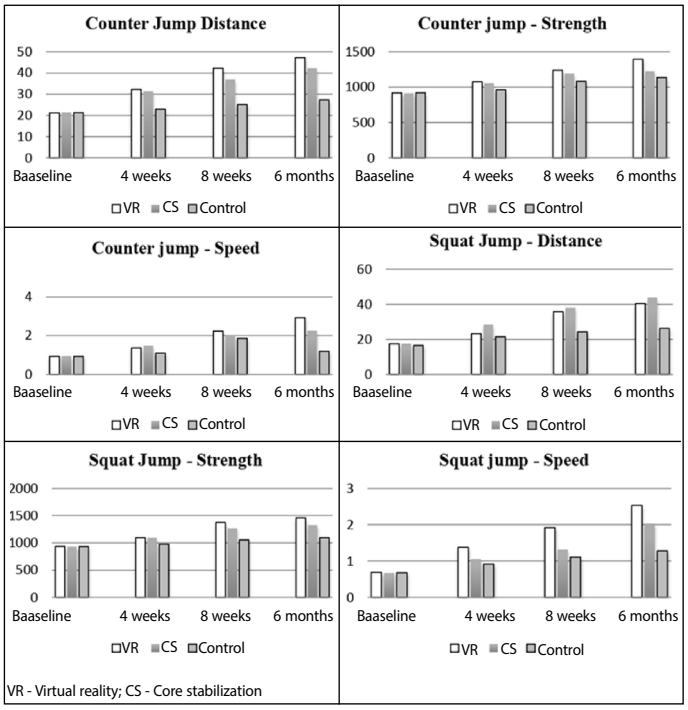

Figure 3. Mean values of counter jump and squat jump scores of VR, CS and control group.

altering the stage of difficulty in virtual reality games improved the overall quality of life by improving the attention, concentration and memory. However, this statement was against by Danneels LA et al and stated that these changes were due to Hawthorne effect.[33]

This trial also analyzed the effects of core stabilization exercise on pain status in LBP participants. The study reported that moderate level of pain reduction in CS group, which was due to the effects of local muscle activation. It was known that the trunk muscle response in chronic LBP was low, and core stabilization exercises facilitated the activation of this muscle recruitment than VR and control group. These changes ultimately led to increase the strength of the core muscles. This increased activation of these muscle fibers was due to the resistance provided by the ball; also the whole procedures were performed under the supervision of trained person. It was explained that positive changes in muscle properties of the core muscles were the root cause of changes in pain status. Stability training activated the nervous system and improved the muscle response which in turn improved the physical efficiency.[28] The active exercises performed in the control group improved the trunk muscle activity by altering the resistance, frequency, mode and duration. However, the exact mechanism behind changes in pain status and physical efficiency in LBP were not defined clearly.[29]

The advantage of this trial was its study methodology and homogenous population; therefore, the study reports can be executed universally to the soccer players with LBP. The players who are highly motivated and trained and familiarity with electronic and virtual resources would get the maximum benefit through this type of virtual training. However, few limitations have been identified while executing this trial. First of all, this trial hasn't found the relation between pain status, quality of life and physical efficiency in LBP. Secondly, long term outcome measurements were not measured and analyzed, which could have been done. Therefore, the future study should focus on to analyze the relation between pain status, quality of life and physical efficiency after different training protocols with measuring long term effects in LBP.

CONCLUSION

The reports of our trial investigated that virtual reality exercise has phenomenal role in improving pain status, quality of life and physical efficiency than stabilization exercise and other traditional exercises in soccer players with low back pain. Hence, virtual reality exercise can be added as a new type of training approach in sports management.

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