Available online at **www.ijmrhs.com**

ISSN No: 2319-5886

International Journal of Medical Research & Health Sciences, 2016, 5, 8:7-16

Comparative study on Virtual Reality Training (VRT) over Sensory Motor Training (SMT) in Unilateral Chronic Osteoarthritis – A Randomized Control Trial

Fathy Abdelazim Awwad Elshazly[1], *Gopal Nambi S.[2] and Tamer Emam Elnegamy[2]

[1]*Prof and Head of Department, Physical therapy and Health rehabilitation, College of Applied Medical Sciences, Prince Sattam Bin Abdul Aziz University, Al-Kharj, Saudi Arabia*
[2]*Asst. Professor, Physical therapy and Health rehabilitation, College of applied medical Sciences, Prince Sattam Bin Abdul Aziz University, Al-Kharj, Saudi Arabia*
Corresponding E-mail: physio_gopal@rediffmail.com

ABSTRACT

Osteoarthritis is a common rheumatologic disease. Several non operative interventions have been described for the treatment. But the available evidences of comparing the effectiveness of Virtual reality training over sensory motor training are very few. So, the purpose of this study is to compare the effectiveness of Virtual reality training over sensory motor training in the treatment of Osteoarthritis. 60 subjects who fulfilled the inclusion and exclusion criteria were divided into three Groups (1, 2 & 3) with randomized sampling method. Group 1 treated with Virtual reality training (VRT), Group 2 treated with sensory motor training (SMT) and Group 3 (control) treated with conventional exercise training (CET). The duration of the treatment was three times per week for 8 weeks in all the three groups. Subjects were assessed at baseline, at 4th and 8th week. Pain Intensity by Visual Analog scale (VAS), Joint Proprioception by Perception Sense, Functional Disability by WOMAC Score, and Quality of Life by HRQOL score were measured. A statistically significant ($p \leq 0.05$) difference between all the 3 groups were noted at the period of 8 week for pain intensity, joint proprioception, functional disability and quality of life. Group-1 treated with (VRT) shows more significant improvement in all parameters compared with Group-2 (SMT) and Group-3 (CET). In conclusion, the addition of virtual reality training to conventional training exercises could improve pain and proprioception which subsequently improve the functional level and quality of life of OA patients.

Keywords: Virtual reality training, Sensory motor training, Conventional exercise training, Osteoarthritis

INTRODUCTION

Osteoarthritis (OA) is the second most common rheumatologic problem next to soft tissue rheumatism. It is one of the leading causes of disability among elderly men and women. Some degree of osteoarthritis develops in everyone by the age of 65 years and approximately 80 % have radiographic evidence by age of 75 years.[1] Recent studies show that Radiographic OA was seen in 89 out of 167 males (53.3%) and in 81 out of 133 females (60.9%) especially in SaudiArabia.[2]

The pathological changes associated with OA affect not only articular cartilage, but also all joint structures.[3] These changes combine to result in pain, muscle weakness and reduction of joint proprioception[4] all of which lead to loss of function.[5] The presence of knee OA may cause changes that speed up the deterioration of these systems or compound the effects of ageing.[6] Several protocols such as strength training, flexibility exercises and range of motion exercises are available for management of knee OA with the aim of improving overall functional activities.[7] Nevertheless patient complaints often persist and function activities levels cannot be fully restored. Proprioception deficits are documented in patients with knee OA.[8] Proprioceptive training is often neglected during rehabilitation of patients with knee OA. It has been suggested that enhancing sensorimotor function can lead to improvement of functional performance in patients with knee OA.[9]

Virtual Reality Training (VRT) represents a promising area for the health care professionals with high potential of enhancing the training in various medical conditions. Emerging changes in physical therapy services specially VRT having significant impact on the treatment of osteo arthritis in proprioceptive perspective. It can provide a rich, interactive, engaging educational context, thus supporting experiential learning-by-doing; it can, in fact, contribute to raise interest and motivation in trainees and to effectively support skills acquisition and transfer, since the learning process can be settled within an experiential framework.[10,11]

Sensori motor training (SMT) was developed by Dr. Vladimir Janda as part of a treatment approach to chronic musculoskeletal pain syndromes. It emphasizes postural control and progressive challenges to the sensorimotor system to restore normal motor programs in patients with chronic musculoskeletal pain. Patients progress through static, dynamic, and functional phases using simple rehabilitation tools such as balance boards, foam pads, and elastic bands.[12] The proprio sensory system helps the motor system to maintain equilibrium on a reflex, automatic basis.[13] In response to a sudden load, "the muscles will respond rapidly to stabilize the body, i.e., they will try to maintain balance and posture."[14]

Conventional exercise raining (CET) has been shown to be successful in remedying many of these conditions. Balogun, et al., showed that balance board training could be a very efficient tool in rehabilitation because it actually produced greater lower extremity strength gain so far longer.[15]

Despite the large quantity of research published regarding the treatment of various aspects OA, no single intervention has been demonstrated and proved to be the most effective protocol exists for balance training in OA rehabilitation. However, there are no objective data to determine the best conservative approach for this syndrome, since the biomechanical and the neurophysiologic perspective and function on VRT and SMT are considerably different.

The objective of the study is to compare the effectiveness of Virtual Reality training (VRT), Sensory motor training (SMT) and Conservative Exercise Training (CET) to reduce pain, improve proprioception, functional disability and Quality of Life in Unilateral Chronic Osteoarthritis.

MATERIAL AND METHODS

Design: Randomized controlled design.
Participants: Totally 110 subjects with the diagnosis of OA subjects were recruited and assessed for the study from University hospital and the study was conducted in Department of physical therapy, Prince Sattam Bin Abdul Aziz University, Al-Kharj, Saudi Arabia during the period of May 2015 to Apr 2016.

Selection criteria: 60 subjects who fulfilled the inclusion and exclusion criteria were assigned for the study. The subjects were included if, 1) age between 35 - 65 years, 2) males and females, 3) Chronic (with symptoms for more than 3 months), 4) able to walk at least 30 feet with or without an assistive device and without physical assistance, 5) not practicing in any sports or physical therapy sessions, 6) willingness to do physical exercise three times a week with regular attendance.

The participants were excluded if they have acute medical problems, Knee surgery within 6 months, Metal implants, Peripheral vascular Disease, Any local or systemic infections, Febrile patients, Mentally deficit patients, Fracture of femoral or tibial condyle, Joint effusion, Abnormal Laboratory Findings, Systemic or Psychiatric illness, Taking Corticosteroids since last 30 days, Suspicious of Cancer, Osteomyelitis, Gout or any other disease that contra indicated the treatment program.

Procedure: After institutional ethical approval, all the participants completed detailed assessment. Prior to participation in this study total 110 participants from University Hospital were recruited into the study, out of them 90 were willing to participate into the study. Out of 90, 60 participants were selected for the study as 20 participants weren't fulfil the inclusion criteria and rest 10 participants were randomly excluded from the study using random number table method. So, total 60 participants were selected for the study.

Prior to participation participants were instructed and explained about the intervention procedure. Pre participation evaluation form consisted of general demographic details of participant and general examination. The selection and allocation of participants was done by using random number table sampling method. A total 60 subjects were selected for study and assigned into three groups (VRT group, SMT group and CET group) randomly (n=20) each group. Participants who were found suitable for the participation were requested to sign consent form. Procedures followed were in accordance with the ethical standards of experimentation (institutional or regional) and with the Helsinki Declaration of 1975, as revised in 2000.

Group 1: [Virtual Reality Training + Conventional Exercise Training].
Group 2: [Sensory Motor Training + Conventional Exercise Training]
Group 3: [Conventional Exercise Training]

Outcome measures:

1. Pain Intensity: - VAS Score

The participants will be asked to mark their intensity of pain on a 10 cm long line marked with numbers 0 on one end and 10 on other end and 10 on other, where 0 indicated no pain and 10 will be maximum pain. Pain Intensity scores (at rest, during motion) will be evaluated before and after treatment with 10- cm Visual Analog Scale.[16]

2. **Joint Proprioception: Perception Sense**

Position sense tests: In these tests the knee is moved (actively or passively) towards a criterion angle. After a few seconds the knee is returned to the original position. Following this, the subject has to reproduce the perceived angle with the same or contra lateral knee, or show the perceived angle on a knee model which is measured with Goniometer.[17]

3. **Functional Disability: - WOMAC Score**

WOMAC Score will be calculated by asking questions to the subjects on 3 sections. Section A for pain and Section B for stiffness and Section C for functional disability. Subjects will be asked to mark their score out of 5 grades of severity, i.e. no pain, mild pain, moderate pain, sever pain, and extreme pain by marking the grade on a line representing the 5 grades.[18]

4. **Quality of Life: HRQOL Score**

The Centers for Disease Control and Prevention has developed a brief set of HRQOL items. It has been shown to perform well in individuals with Musculo skeletal pain. The CDC HRQOL assumes that HRQOL is a fundamentally subjective construct whose core features (physical and mental health appraisal) are expressed through patients' judgments of their general health and the number of days within the past month when they felt physically unhealthy, mentally unhealthy, and limited their activities because of their health.[19]

Intervention

VRT Group received virtual reality training exercises which are focusing on lower limb strength, flexibility, co-ordination and balance. VRT exercise were held in small groups of three or less subjects and lasted for about 15-30 minutes. Exercises were done in sitting as well as in standing position which also challenges balance in its correct execution. All exercises were done for 10 repetitions with a rest period of two minutes before commencing the next exercise. Exercise was progressed in terms of repetitions or advanced method at the earliest opportunity.

The virtual reality interactive game implemented in the present work was Light Race. Light Race consists of its player standing on a virtual platform displayed on the game screen and doing steps on the platform by moving his/her left or right lower limbs back and forth and left and right according to the signs.[20]

Sensory motor training (SMT) group subjects were trained through three stages: static, dynamic and functional. Each exercise was repeated 3–5 times during a session and with enough periods of rest between each set of exercises.

The exercise graduated from easy to more difficult and the patient was not progressed to a more difficult stage until performing the easier one according to the following protocol.[21]

1st and 2nd weeks: First phase (Static)

1. Standing upright position (30 s) on a firm surface, then on a soft surface (a mat).
2. Single leg stance with closed eyes (first the affected limb, then the non-affected limb) for 10 s on a firm surface, then on a soft surface (a mat).
3. Half-step position for 10 s.
4. One-leg balance for 10 s.

3rd and 4th weeks: Second stage (Dynamic), in addition:

1. Forward stepping thrust.
2. T-band kicks exercise

5th and 6th weeks: Third phase (Functional), in addition:
1. Walking exercise on a firm surface, then on a foam surface:
(a) Toe skipping with toes straight ahead for 20 m, toes pointing outward for 20 m and toes pointing inward for 20 m.
(b) Heel skipping with toes straight ahead for 20 m, toes pointing outward for 20 m and toes pointing inward for 20 m.

2. Squatting exercise:
(a) Against a wall and away from the wall.
(b) One leg squats on the affected and non-affected limb.

3. Balance exercise on wobble board:
(a) Multidirectional rolling movement from sitting.
(b) Multidirectional rolling movement from standing on both legs between parallel bars with eyes open, then eyes closed.
(c) Multidirectional rolling movement from standing on one leg between parallel bars with eyes open, then eyes closed.
(d) Balance with two legs, eyes open, multidirectional, then eyes closed.
(e) Balance with one leg, eyes open, multidirectional, then eyes closed.

CET group received intervention in the form of 5 minutes warm up followed by 12 minutes of walking at their comfortable pace and concluded with a 5 minutes cool down. All the groups received the above mentioned interventions three times per week for a period of 8 weeks.

Statistical analysis: Analyses were done using SPSS-18. Descriptive analysis was used to calculate mean and standard deviation. Normality of distribution was verified using Kolmogorov-Smirnov test and found to have normal distribution in all data. Comparison between groups was done using ANOVA and intra group comparison was done by using student's t-test. The level of significance was set at 95%.

RESULTS

Out of ninety two (N=92) subjects sixty subjects (n=60) were eligible to take part in the study and 32 were excluded. Sixty subjects were assessed at baseline and randomly allocated in three different groups. (Virtual reality training (VRT) group (n=20), Sensory motor training (SMT) group (n=20) and Conventional training (CET) group (n=20). All the patients completed the treatment and attended the last assessment.

Analysis of Demographic variables
The mean age (SD) of subjects in VRT, SMT group and CET group was 58 ± 6, 60 ± 8 and 59 ± 7 years old, respectively. The mean height (SD) of subjects in VRT, SMT group and CET group was 168 ± 6, 163 ± 8 and 165 ± 7 cm height respectively. The mean weight (SD) of subjects in VRT, SMT group and CET group was 72 ± 12, 68 ± 10 and 70 ± 12 kg weight respectively. The mean BMI (SD) of subjects in VRT, SMT group and CET group was 26.9 ± 4.8, 28.3 ± 3.5 and 25.6 ± 4.2 kg/m^2 respectively. The p values of all the demographic variables such as age, height, weight and BMI shows insignificant difference ($p > 0.05$) between the groups shows the homogeneity of samples (Table-1).

Inter group Analysis:
Analysis at Baseline:
The mean baseline score of VAS (SD) of subjects in VRT, SMT group and CET group was 6.81 ± 6, 6.62 ± 1.17 and 6.68 ± 0.84 respectively (Fig-1). The mean baseline scores of position sense (SD) of subjects in VRT, SMT group and CET group was 118.9 ± 4.6, 120.5 ± 4.16 and 120.95 ± 3.79 respectively (Fig-2). The mean baseline scores of WOMAC (SD) of subjects in VRT, SMT group and CET group was 71.65 ± 3.43, 71.65 ± 2.75 and 1.55 ± 0.51 respectively (Fig-3). The mean after 8 weeks sores of HRQOL (SD) of subjects in VRT, SMT group and CET group was 1.35 ± 0.48, 1.60 ± 0.5 and 1.55 ± 0.51 respectively (Fig-4). The p values of all baseline values such as VAS, Position, WOMAC and HRQOL score shows insignificant difference ($p > 0.05$) between the groups shows the homogeneity of samples (Table-2).

Analysis after 8 weeks:
The mean after 8 weeks score of VAS (SD) of subjects in VRT, SMT group and CET group was 2.9 ±0.97, 4.53 ± 0.84 and 4.74 ± 0.72 respectively (Fig-1). The mean after 8 weeks scores of position sense (SD) of subjects in VRT, SMT group and CET group was 134 ± 1.16, 126.95 ± 1.93 and 124.45 ± 2.96 respectively (Fig-2). The mean after 8

weeks sores of WOMAC (SD) of subjects in VRT, SMT group and CET group was 14.65 ± 3.13, 34.1 ± 3.85 and 44.75 ± 4.25 respectively (Fig-3). The mean after 8 weeks sores of HRQOL (SD) of subjects in VRT, SMT group and CET group was 4.5 ± 0.6, 3.3 ± 0.47 and 2.5 ± 0.51 respectively (Fig-4). The p values of all baseline values such as VAS, Position, WOMAC and HRQOL score shows significant difference ($p \leq 0.05$) between the groups shows the difference in the effect of groups (Table-2).

Intra group Analysis:

Pain Intensity – VAS score: All the three groups (VRT, SMT and CET) showed significant improvement in the pain intensity with decrease in VAS scores. The VAS total scores for VRT group (6.81 to 2.90), SMT group (6.62 to 4.53) and CET group (6.68 to 4.74) were found to be statistically significant at $p<.05$ (Table 3). Percentage of improvement shows that VRT group shows more significant difference than other two groups (SMT and CET).

Joint Perception – Position Sense: All the three groups (VRT, SMT and CET) showed significant improvement in the Joint Perception with increase in position sense scores. The position sense total scores for VRT group (118.9 to 134), SMT group (120.5 to 126.95) and CET group (120.95 to 124.45) were found to be statistically significant at $p<.05$ (Table 3). Percentage of improvement shows that VRT group shows more significant difference than other two groups (SMT and CET).

Functional Disability – WOMAC score: All the three groups (VRT, SMT and CET) showed significant improvement in the functional disability with decrease in WOMAC scores. The WOMAC total scores for VRT group (71.65 to 14.65), SMT group (71.65 to 34.10) and CET group (71.90 to 44.75) were found to be statistically significant at $p<.05$ (Table 3). Percentage of improvement shows that VRT group shows more significant difference than other two groups (SMT and CET).

Quality of Life – HRQOL score: All the three groups (VRT, SMT and CET) showed significant improvement in the quality of life with increase in HRQOL scores. The HRQOL total scores for VRT group (1.35 to 4.5), SMT group (1.6 to 3.3) and CET group (1.55 to 2.5) were found to be statistically significant at $p<.05$ (Table 3). Percentage of improvement shows that VRT group shows more significant difference than other two groups (SMT and CET).

DISCUSSION

This study compares the effects of virtual reality training (VRT), sensory motor training (SMT) and conventional training (CET) on pain intensity, proprioception, functional disability and quality of life in patients with knee OA. The results establish that there was significant improvement in outcome measures in all the training methods; however VRT showed a substantial improvement over the other methods.

This study uses the 360 Kinetic sensors on OA subjects for eight weeks in the VRT group. Virtual reality interface game are considered as an intervention that can safely be applied to OA patients, however studies using Nintendo Wii Fit applied the modified format of the game due to safety concerns.[11]

Studies report the association between OA and loss of proprioception, muscle weakness and pain.[22]The gate control theory of pain modulation states that an increase in afferent stimulates to large diameter nerve fibres serves to stimulate the input received from the small diameter nerve fibres conducting nociception. This can be the plausible explanation for the changes observed in the VRT and SMT group.[23]

The SMT group showed more significant reduction of pain than the CET group. In chronic OA the patient is usually entrapped in a physical reconditioning cycle where the patient tries to compensate for his pain by adapting unnatural and restricted posture (patellar mal alignment leads to increased peak patella femoral pressure forces) this may lead to pain, muscle spasm and reduced joint range of motion.[24] CET such as exercise is thought to improve patellar alignment by correct tracking of the patella.[25]

In the present study, both the VRT and SMT showed significant improvement in proprioception after training. This result was obtained because patients' motivation was increased through the virtual reality games, encouraging their active participation and improving their concentration. Proprioception is essential to improve balance in intervention methods using open and closed eye condition in OA subjects. Virtual reality interactive games are considered to influence the proprioception in older women with osteoarthritis.[26]

This study proves that SMT produced significant improvement in proprioception than CET. SMT restores motor control through maximizing sensory input from joint receptors to improve proprioception, joint stability and overall function level of the patient through central integration.[27] In SMT each exercise stimulates the automatic and reflective muscular stability through different body postures and base of support which challenges the centre of gravity to maintain posture.[28] It also maintains the functional joint stability through complementary relationships between static and dynamic restraints. The similar results has been obtained by the studies proving that SMT affects proprioception more than classic traditional exercise program through improving sensory input to the central nervous system and improving function of the knee joint.[29]

Pain decreases activation level of the muscle and guard their physical activities which in turn aggravates the disability.[30] VRT like (Light Race and Virtual Smash games) generate appropriate levels of joint and trunk movements which improve functional disability like walking and activities of daily living in subjects with osteoarthritis.[31] Subjects were informed of their game results and allowed to share with other subjects which encourage the active participation in the study. Previous studies also reported that motivation and active participation produces better functional results.[32]

VRT games like bowling, skiing and golf induce movements which require the lower extremity to support the body weight, trunk stability and accurate control of the movements which improve the functional ability. Similar effects can also be obtained by gait exercises such as ground walking, walking with obstacles, and walking over stairs repeatedly. Also the visual and auditory feedback enhances the functional performance of subjects in SMT. It is unclear and extremely difficult to analyse the complex interactions and relationship in SMT.[33] The results of the study has been supported by Demirhan et al., 2005 and YihTsauo et al. 2008 showed significant positive changes in the SMT group compared with the strengthening group in functional performance, pain and proprioception respectively.[34]

The current results show that there was significant positive correlation between proprioception and functional activity level at baseline and after exercise which was in agreement with the study of Hassan et al[35] Also, Hurley et al. studied the sensory motor changes and functional performance in patients with knee OA and concluded that decreased postural stability was associated with reduced functional performance.[36] CVT should increase neuromuscular control and meet the needs of daily activities.[37]

Comparing all other measured parameters, VRT group produced statistically significant improvements in quality of life. There are studies which investigated the effect of SMT and CVT training in the management of knee OA and reported decreased pain and increased proprioception with consequent improvement in quality of life.[38,39,40]

Table-1: Demographic variables of VRT, SMT and CET group:

	VRT Group	SMT Group	CET Group	p - value
Age(Years)	58 ± 6	60 ± 8	59 ± 7	0.670
Height (cm)	168 ± 6	163 ± 8	165 ± 7	0.087
Weight (kg)	72 ± 12	68 ± 10	70 ± 12	0.542
BMI (Kg/m^2)	26.9 ± 4.8	28.3 ± 3.5	25.6 ± 4.2	0.136

VRT – Virtual reality training, SMT – Sensory Motor Training, CET – Conventional exercise training

Table-2: Inter group comparison between VRT, SMT and CET in Pain, Position sense, WOMAC and HRQOL score.

	Base line (T1)				After 8 Weeks (T3)			
	VRT Group	**SMT Group**	**CET Group**	**p - value**	**VRT Group**	**SMT Group**	**CET Group**	**p - value**
VAS score	6.81±0.87	6.62±1.17	6.68±0.84	0.819	2.9±0.97	4.53±0.84	4.74±0.72	0.000
Position sense	118.9± 4.6	120.5±4.16	120.95±3.79	0.276	134±1.16	126.95±1.93	124.45±2.96	0.000
WOMAC score	71.65±3.43	71.65±2.75	71.9±3.05	0.957	14.65±3.13	34.1±3.85	44.75±4.25	0.000
HRQOL score	1.35±0.48	1.60±0.5	1.55±0.51	0.251	4.5±0.6	3.3±0.47	2.5±0.51	0.000

VRT – Virtual reality training, SMT – Sensory Motor Training, CET – Conventional exercise training
VAS – Visual Analog Scale, WOMAC – Western Ontario and Mc Master University, HRQOL – Health related quality of life

Table-3: Intra group comparison of VRT, SMT and CET in Pain, Position sense, WOMAC and HRQOL score.

	VRT Group (n=20)			p-value	SMT Group (n=20)			p-value	CET Group (n=20)			p-value
	T1	**T2**	**T3**		**T1**	**T2**	**T3**		**T1**	**T2**	**T3**	
VAS score	6.81± 0.87	3.71± 1.1	2.9± 0.97	0.000	6.62± 1.17	5.43± 0.96	4.53± 0.84	0.000	6.68± 0.84	5.37± 0.85	4.74± 0.72	0.000
Position sense	118.9± 4.6	127.6± 2.06	134± 1.16	0.000	120.5± 4.16	123.45± 2.28	126.95± 1.93	0.000	120.95± 3.79	123.1± 3.29	124.45 ±2.96	0.007
WOMAC score	71.65± 3.43	39.8± 7.83	14.65± 3.13	0.000	71.65± 2.75	53.25± 3.75	34.1± 3.85	0.000	71.9± 3.05	54.1± 6.10	44.75± 4.25	0.000
HRQOL score	1.35± 0.48	3.05± 0.51	4.5± 0.6	0.000	1.6± 0.5	2.5± 0.51	3.3± 0.47	0.000	1.55± 0.51	2.22± 0.44	2.5± 0.51	0.000

VRT – Virtual reality training, SMT – Sensory Motor Training, CET – Conventional exercise training
VAS – Visual Analog Scale, WOMAC – Western Ontario and Mc Master University, HRQOL – Health related quality of life

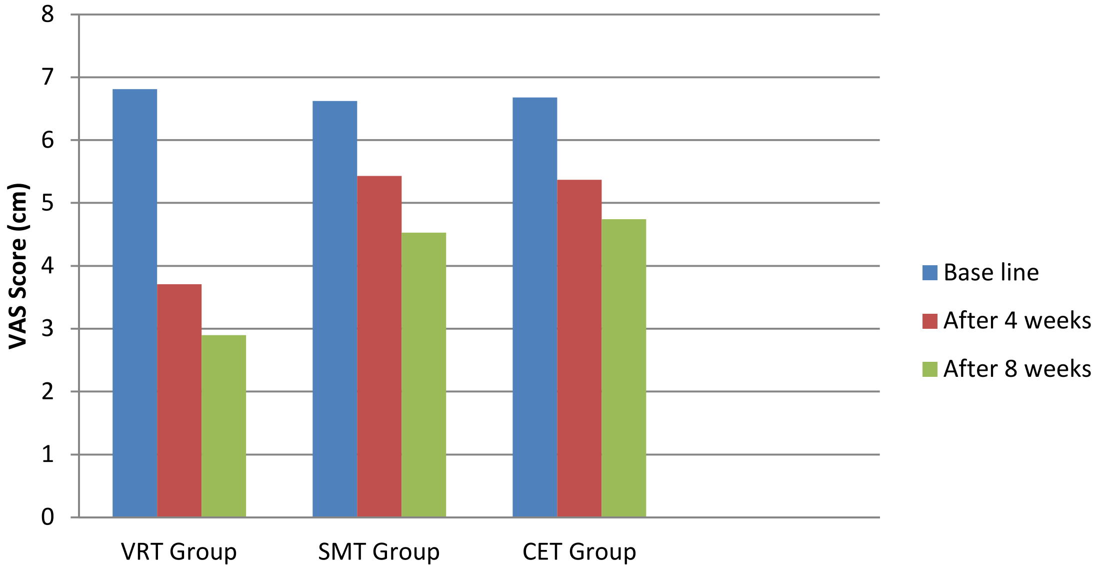

Figure - 1: Pain intensity (VAS) score of VRT, SMT and CET group at Baseline, 4 weeks and 8 weeks.

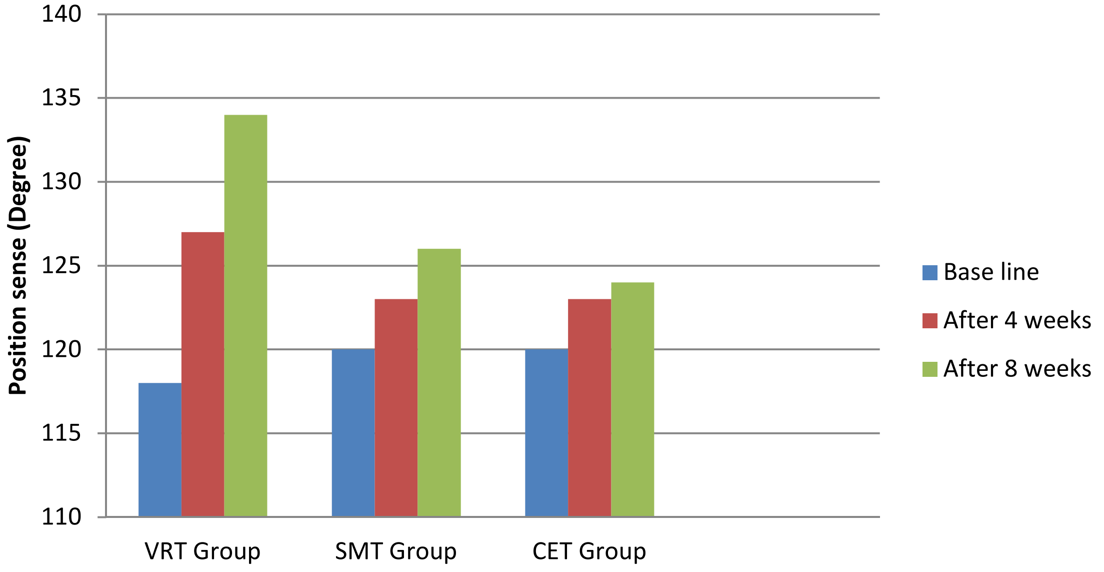

Figure - 2: Position sense (Degree) score of VRT, SMT and CET group at Baseline, 4 weeks and 8 weeks.

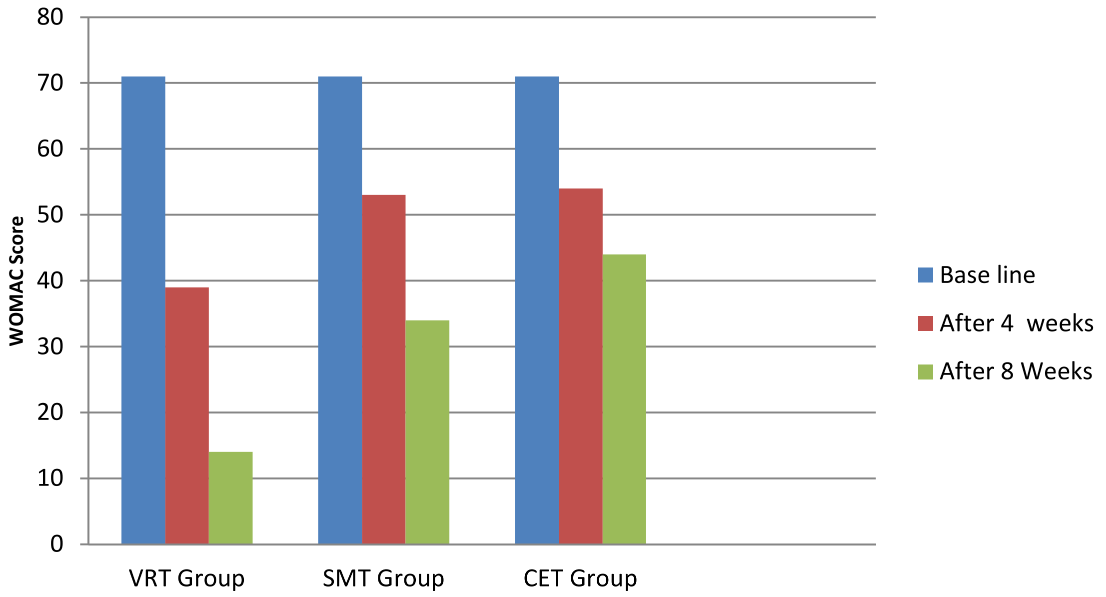

Figure - 3: WOMAC score of VRT, SMT and CET group at Baseline, 4 weeks and 8 weeks.

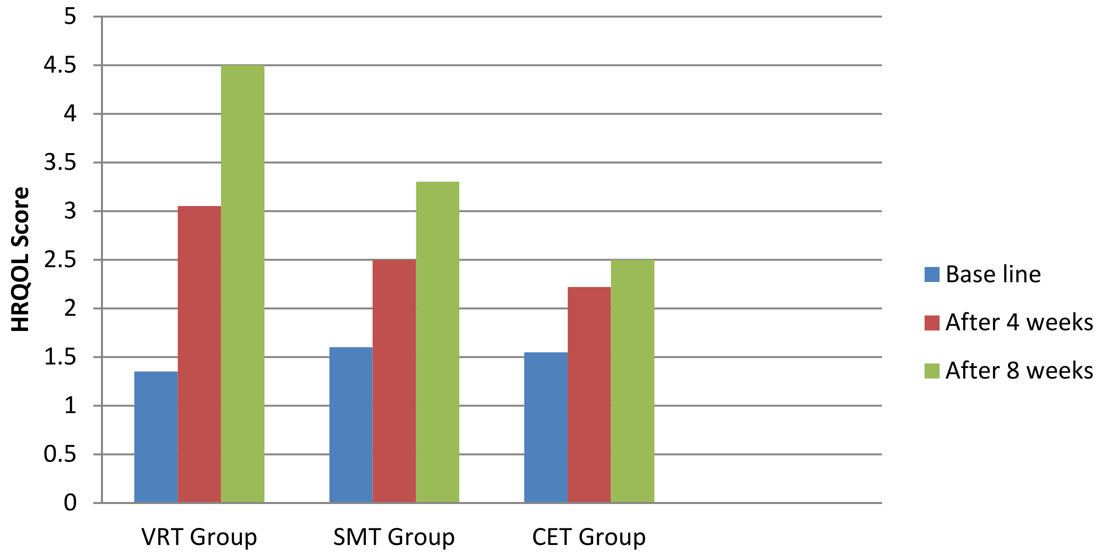

Figure - 4: HRQOL score of VRT, SMT and CET group at Baseline, 4 weeks and 8 weeks.

In conclusion, the addition of virtual reality training to conventional training exercises could improve pain and proprioception which subsequently improve the functional level and quality of life of OA patients. Also, the close association between pain, proprioception and functional level should be kept in mind during rehabilitation of knee OA. However, as the current study investigates the short term effect of virtual reality training, studies with long term follow up are needed. Ultimately, it might be feasible to include virtual reality training in the management protocol of patients with knee OA.

Acknowledgement
Authors are grateful to the deanship of scientific research, Prince Sattam Bin Abdul Aziz University, Saudi Arabia for financial support to carry out this work no – 2015/03/4217.

REFERENCES

[1] Chopra, I., Hodgson, J., Metcalf, et al. The search for anti microbial agents effective against bacteria resistant to multiple antibiotics. Antimicrobial Agents and Chemotherapy. 1997;41:497–503.
[2] Al-Arfaj A, Al-Boukai AA. Prevalence of radiographic knee osteoarthritis in Saudi Arabia. Clin Rheumatol. 2002;21(2):142-5.
[3] Felson DT. Developments in the clinical understanding of osteoarthritis. Arthritis Res Ther2009;11(1):203–24.
[4] Shakoor N, Agrawal A, Block JA. Reduced lower extremity vibratory perception in osteoarthritis of the knee. Arthritis Care Res 2008;59(1):117–21.
[5] Neogi T, Nevitt M, Zhu Y, Xie H, Curtis JR, Clark ECea. Inconsistent knee pain: prevalence, predictors and association with function. Osteo arthr Cartilage 2006;14(Suppl. 2):S120–1.
[6] Verzijl N, Bank RA, TeKoppele JM, DeGroot J. Ageing and osteoarthritis: a different perspective. CurrOpinRheumatol2003;15(5):616–22.
[7] Huang MH, Lin YS, Yang RC, Lee CL. A comparison of various therapeutic exercises on the functional status of patients with knee osteoarthritis. Semin Arthritis Rheum 2003;32(6): 398–406.
[8] Allum JH, Carpenter MG, Adkin AL. Balance control analysis as a method for screening and identifying balance deficits. Ann NY AcadSci2001;942:413–27.
[9] Roos EM. Joint injury causes knee osteoarthritis in young adults. Curr Opin Rheumatol 2005;17(2):195–200.
[10] Schultheis MT, Rizzo AA. The application of virtual reality technology in rehabilitation. Rehabilitation Psychology 2001; 46(3): 296-311.
[11] Laver K, Ratcliffe J, George S et al. Is the Nintendo Wii Fit really acceptable to older people? A discrete choice experiment. BMC Geriatr. 2011; 11:64.
[12] Phil Page, Sensorimotor training: A ‘‘global’’ approach for balance training. Journal of Bodywork and Movement Therapies 2006;(10): 77–84.
[13] Winter DA 1995. Human balance and posture control during standing and walking. Clin Biomech, 3(4)193-214.
[14] Wilder DG, Aleksiev AR, Magnusson ML, Poper MH, et al., 1996. Muscular response to sudden load. Spine 21 (22):2628-2639.
[15] Bologun JA, Adesinasi CO, Marzouk DK 1992. The effects of a wobble board exercise training program on static balance performance and strength of lower extremity muscles. Physio ther Can 44:23-30.
[16] Bullock-Saxton JE, Janda V, Bullock MI 1993. Reflex activation of gluteal muscles in walking. Spine, 18:6;704-708.
[17] Ihara H, Nakayama A 1986. Dynamic joint control training for knee ligament injuries. Am J Sports, Med 14(4);309-31.
[18] Wegener L, Kisner C, Nichols D 1997 Static and dynamic balance responses in persons with bilateral knee osteoarthritis. Journal of Orthopaedic Sports Physical Therapy 25: 13±18.
[19] O’Connell M, George K, Stock D 1998. Postural sway and balance testing: a comparison of normal and anterior cruciate ligament deficient knees. Gait and Posture 8:136-142.
[20] Sam-yeol Wi, Jong-ho Kang. The Effects of Virtual Reality Interactive Games on the Balance Ability of Elderly Women with Knee Osteoarthritis. Journal of physics. 2012; 7(3): 387-393.
[21] Riemann BL, Lephart SM. The sensorimotor system. Part I: The physiologic basis of functional joint stability. J Athlet Train 2002;37(1):71–9.
[22] Felson DT, Niu J, McClennan C, Sack B, Aliabadi P, Hunter DJ, et al.. Knee buckling: prevalence, risk factors and associated limitations in function. Ann Intern Med 2007;147(8):534–40.
[23] Kneeshaw D.: Shoulder taping in the clinical setting. J Bodywork Movement Ther. 2002;6:2-8.
[24] Felson DT. Developments in the clinical understanding of osteoarthritis. Arthritis Res Ther2009;11(1):203–24.
[25] Doucette SA, Goble EM. The effect of exercise on patellar tracking in lateral patellar compression syndrome Am J Sports Med 1992;20(4):434-40.
[26] Willems T, Witvrouw E., Verstuyft J et al. Proprioception and muscle strength in subjects with history of ankle sprain and chronic instability. J Athl Train. 2002;37(4):487-93.
[27] Riemann BL, Lephart SM. The sensorimotor system. Part II: The role of proprioception in motor control and functional jointstability. J Athlet Train 2002;37(1):80–4.
[28] Kapreli E, Athanasopoulos S, Papathanasiou M, Van Hecke P, Kelekis D, Peeters R, et al.. Lower limb sensorimotor network: issues of somatotopy and overlap. Cortex 2007;43(2): 219–32.
[29] Meenan RF, Gertman PM, Mason JH.: Measuring health statusin arthritis. The arthritis impact measurement scales. Arthritis Rheum 1980;23(2):146–52.
[30] Arvidsson I, Eriksson E, Knutsson E, Arner S. Reduction of pain inhibition on voluntary muscle activation by epidural analgesia. Orthopedics1986;9(10):1415–9.
[31] Agmon M, Perry CK, Phelan E et al. A pilot study of Wii Fit exer games to improve balance I older adults. J Geriatr Phys Ther. 2011;34(4): 161-7.

[32] Maclean N, Pound P, Wolfe C et al. Qualitative analysis of stroke patients' motivation for rehabilitation. BMJ. 2000;321(7268):1051-4.
[33] Lephart SM, Riemann Bl and Fu FH. Introduction to the sensorimotor system. In: Lephart SM, Fu FH, eds.: Proprioception and Neuromuscular Control in Joint Stability. Champaign, IL: Human Kinetics; 2000.
[34] Jau-Yih T., Pai-Fu C., and Rong-Sen Y.: The effect of sensorimotor training on knee proprioception and function for patients with knee osteoarthritis: a preliminary report. Clinical Rehabilitation 2008; 22:448-457.
[35] Hassan BS, Mockett S, Doherty M. Static postural sway, proprioception, and maximal voluntary quadriceps contraction in patients with knee osteoarthritis and normal control subjects. Ann Rheum Dis 2001;60(6):612–8.
[36] Hurley MV, Scott DL, Rees J, Newham DJ. Sensorimotor changes and functional performance in patients with knee osteoarthritis. Ann Rheum Dis 1997;56(11):641–8.
[37] Dinesh Bhatia, Tatiana Bejarano, Mario Novo. Current inventions in the management of knee osteo arthritis. J pharm Bio allied Sci 2013;5(1):30-38.
[38] Huang MH, Lin YS, Yang RC, Lee CL. A comparison of various therapeutic exercises on the functional status of patients with knee osteoarthritis. Semin Arthritis Rheum 2003;32(6): 398–406.
[39] Deyle GD, Allison SC, Matekel RL, Ryder MG, Stang JM, Gohdes DD, et al.. Physical therapy treatment effectiveness for osteoarthritis of the knee: a randomized comparison of supervised clinical exercise and manual therapy procedures versus a home exercise programme. Phys Ther2005;85(12): 1301–17.
[40] Hurley MV, Scott DL. Improvements in quadriceps sensorimotor function and disability of patients with knee osteoarthritis following a clinically practicable exercise regime. Br J Rheumatol 1998;37(11):1181–7.