

Original Research Article

## **Effect of virtual reality training on psychosocial factors after anterior cruciate ligament reconstruction: a clinical trial**

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**Abstract:** There is a growing consensus regarding the influence of psychosocial factors on reduced rate of return to sports and risk of re-injury after anterior cruciate ligament reconstruction (ACLR). Virtual reality training has been used as an effective mode of training in sports rehabilitation to address the physical impairments however, its effect in addressing the psychosocial impairments has not been studied. The aim was to study the effect of virtual reality training using Xbox Kinect on psychosocial factors in patients after ACLR. In this, 25 participants between the age group of 18-30 years who were 6 weeks post-operative after ACLR with or without meniscectomy were included in the study. The psychosocial factors such as kinesiophobia, pain catastrophizing levels and Self-efficacy for rehabilitation were assessed pre and post the treatment. Treatment was given by Virtual reality training using Xbox Kinect for 4 weeks, 5 times per week. Pre and post differences were measured using Wilcoxon sign rank test which suggested a significant difference ( $p < 0.05$ ) for all the parameters after 4 week of training. Virtual reality training using Xbox Kinect was effective in improving the psychosocial factors in patients after ACLR.

**Keywords:** Xbox, Psychosocial, ACL, Kinesiophobia, Self-efficacy

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### **INTRODUCTION**

Anterior cruciate ligament (ACL) injury is the commonly seen knee ligament injury in field sports affecting the functional capabilities and performance in an athlete [1]. These injuries are commonly managed surgically by arthroscopic evaluation and ACL reconstruction (ACLR) [2]. ACLR restores the mechanical dysfunction of the knee however; an appropriate rehabilitation program is required to re-establish the normal functional pattern. Although it has been expected that the athlete should return to unrestricted activities, pre-injury status, and sports after complete rehabilitation, few studies have reported that almost 20% to 50% athletes did not return to sports and 10% to 70% participated with reduced activity level [3]. Reasons for these problems can be discontinuation of the physical therapy program after the primary impairments of pain, range of motion and strength are resolved [4]. Along with the physical rehabilitation, psychosocial rehabilitation also plays an important role after ACLR [4, 5]. Recent studies have shown that

trauma causes psychological responses like anger, anxiety, depression etc. along with the physical impairments and these responses are amplified after severe injury such as a traumatic ACL injury. A referral for psychological counselling along with physical therapy can eliminate these psychological issues to facilitate overall recovery of the athlete [6].

Three distinct psychosocial (interrelation of psychological and social problems) factors specific to this patient population have been described by Chmielewski *et al.*; which can hamper the recovery [7]. Kinesiophobia (a fear of movement/ re-injury) measured by Tampa Scale of Kinesiophobia (TSK) is considered as a potential psychosocial factor impeding an athletes' return to sports [4, 5, 7]. TSK levels were found to be increased in athletes even after rehabilitation post ACLR [5].

This increased fear of injury post ACLR may also increase the risk of re-injury [5, 7]. Similarly, pain

catastrophizing levels and self-efficacy are another two psychosocial factors which are reported to affect the return to sport criteria in the athletes [7]. Pain catastrophizing reflects a negative cognitive or affective reaction to an anticipated pain experience and has been shown to influence the knee pain levels in young athletes [8, 9]. Self-efficacy is assessed by a person's potential ability to perform a given task. Self-efficacy Rehabilitation Outcome survey (SER), used in this study has been proved to evaluate a person's belief in ability to perform rehabilitation after hip or knee surgery [7]. These measures have been verified to be associated with the knee function and neuromuscular control after ACLR [7, 8]. Rehabilitation focusing on the psychosocial factors is not frequently addressed in the current clinical scenario [6]. Hence, there is a need for a better training tool which will help to address these deficiencies.

Xbox Kinect system, a non-immersive type of virtual reality training has been extensively used in the current clinical settings for the neuromuscular training. Studies have proved its efficacy in improving balance in competitive athletes with chronic ankle problems [10]. This type of technology has shown promising results in improving the overall functional status of the patients and also causing behavioural changes in them [10]. Improvements in the psychological and behavioural aspects have been considered as the main advantage in implementation of this training over a traditional approach [10]. However, its efficacy has not been studied in the psychosocial rehabilitation after ACLR. Hence, we aimed to study the effectiveness of Xbox Kinect intervention on psychosocial factors after ACLR. We hypothesized that this intervention would be beneficial in improving the psychosocial measures in patients after ACLR.

## **METHOD**

The study was conducted at an out-patient department of Orthopedics and Sports Medicine centre. The study was approved by the Institutional Ethics Committee. An informed written consent was taken from all the participants. In this pre-post type of study, a total of 50 patients who were 6 weeks post-operative after ACL reconstruction between the age group of 18-30 years (mean and standard deviation of 25.2 +/- 4.67) were collected using simple random sampling and were screened for the eligibility criteria.

The inclusion criteria were patients who had undergone ACLR with or without meniscectomy 6 weeks before, knee range of motion of a minimum 0-110 degrees and muscle strength of a minimum of grade

4 out of 5 on Manual Muscle Testing. All the patients should have followed the standard rehabilitation protocol. Patients who had an associated collateral ligament and cartilage injury, fracture and bilateral injury were excluded from the study. A total of 25 patients fulfilled the inclusion criteria and participated in the study. The experimenter informed about the research protocol and answered all the questions. Demographic data such as age, gender and body mass index were recorded initially. Assessment for kinesiophobia, pain catastrophizing and self-efficacy was performed prior to the commencement of training. Kinesiophobia was evaluated by using original version of Tampa Scale for Kinesiophobia (TSK). TSK is a 17-item scale which measures the somatic sensations or activity avoidance and are scored from 1('strongly disagree') to 4('strongly agree'). Higher the score, higher is the pain-related fear of movement [7, 11, 12].

Pain catastrophizing is measured by Pain Catastrophizing Scale (PCS) which is a 13-item scale focusing on rumination, magnification and helplessness of pain. In this questionnaire, each item is scored between 1('not at all') to 4('all the time'). The scores are summed to create a total score ranging from 0 to 52 points with higher points indicating higher pain catastrophizing levels [7, 11]. Self-efficacy is measured using SER which is a 12-item questionnaire where the patient is asked to score on 11 point Likert scale (0='I cannot do it' and 10='Certain I can do it'). The scores are summed to form a total score ranging between 0 to 120 points. Higher the score greater is the self-efficacy to perform rehabilitation [7].

Following the above evaluation, participants were trained by using Xbox Kinect system and Xbox Adventure games [10]. These games focused on improving the overall knee function and neuromuscular control in the participants. Prior instructions were given to the patient to avoid any high impact activity like hopping or jumping. The subjects were given a demonstration by the gaming system about the way the game is to be played. Subject's body image and movements of the arms and legs were detected by the Kinect sensor and it was depicted on the TV screen. The balance games and the progression of each exercise are given in Table 1. All the participants wore functional knee brace while performing the games and training was under the supervision of a trained physical therapist to ensure the safety of the participants.

All participants received strengthening exercise program which is the part of the standard rehabilitation program after ACLR. The program

included Double squat, bilateral heel raises, hamstring curl with resistance, dynamic quadriceps with resistance and hip abduction in side-lying with resistance [3]. This training in a controlled environment was given for 4 weeks, 5 days per week. The treatment time was 30-45 min for each session. The session began with warm-up exercises involving stationery bicycle for 10 minutes followed by the balance and strength training program and cool down exercises for 5 minutes at the end. Post-intervention assessment was done for the psychosocial factors using TSK, PCS and SER scales and the scores were recorded.

**STATISTICAL ANALYSIS**

Analysis was done by using Statistical Package for Social Sciences (SPSS) version 23. Analysis was performed on 20 participants. Wilcoxon signed rank test

was used to compare the pre and post data of TSK, PCS and SER. Level of significance was  $p < 0.05$ .

**RESULTS-**

Subjects who participated in the study were males with mean age of 25.2 +/- 4.67 years and mean body mass index of 24.61 +/- 1.23 kg/cm<sup>2</sup>. Mean and standard deviation values for TSK, PCS and SER are illustrated in Table 2. Pre-post comparison showed a significant difference ( $p < 0.05$ ) in all the three outcome measures.

**CLINICAL IMPLICATION**

We recommend the use of Xbox Kinect and Kinect Adventure games for improving the psychosocial factors like fear of re-injury, pain catastrophizing and self-efficacy level in the late rehabilitation phase of ACLR.

**Table 1: Xbox Adventure games with game description and their week wise progression.**

Games	20,000 Leaks	River rush	Rally ball	Space pop	Reflex bridge
Game description	Subject's avatar is in a glass cube underwater and the player positions his limbs to plug the leaks in the glass cube.	Subjects stand in a raft and the raft is controlled by stepping right or left and squatting.	The player uses his upper limbs to hit the balls at the targets which are at the end of the virtual hallway. The balls split into multiple balls which can be handled simultaneously.	Soap bubbles shuttle between the holes on the walls, floors and ceiling of a virtual room. The subject attempts to pop them by touching them	Subject is on a virtual moving platform. Subject has to walk on the platform, bend and lean to avoid the obstacles.
1 <sup>st</sup> week	2 repetitions of 3 min each in the basic free play mode. 1min rest interval	2 repetitions of 3 min each in the basic free play mode. 1min rest interval	2 repetitions of 3 min each in the basic free play mode .1 min rest interval	2 repetitions of 3 min each in basic free play mode. 1 min rest interval	
2 <sup>nd</sup> week	2 repetitions of 3 min each in the intermediate mode. 1 min rest interval	2 repetitions of 3 min each in the intermediate mode. 1 min rest interval	2 repetitions of 3 min each in the intermediate mode. 1 min rest interval	2 repetitions of 3 min in the intermediate mode. 1min rest interval	
3 <sup>rd</sup> week	2 repetitions of 3 min each in the advanced mode. 1 min rest interval.	2 repetitions of 3 min each in the intermediate mode. 1 min rest interval		2 repetitions of 3 min in the advanced mode. 1 min rest interval	2 repetitions of 3 min in the basic free play mode. 1 min rest interval
4 <sup>th</sup> week	2 repetitions of 3 min each in the advanced mode. 1 min rest interval		2 repetitions of 3 min each in the advanced mode. 1 min rest interval		2 repetitions of 3 min each in the intermediate and advanced mode. I min rest interval

**Table 2: Pre and post comparison between the psychosocial factors (TSK, PCS and SER)**

Sr no.	Outcome measures	Pre-intervention (Mean +/- S.D.)	Post-intervention (Mean +/- S.D.)	p-value
1	TSK	41.60 +/- 4.198	35.90 +/- 7.615	0.003*
2	PCS	16.85 +/- 7.073	7.30 +/- 4.281	0.00*
3	SER	80.95 +/- 18.438	114.05 +/- 4.161	0.00*

Abbreviations: TSK- Tampa Scale for Kinesiophobia, PCS- Pain Catastrophizing Scale, SER- Self-efficacy Rehabilitation Outcome survey, S.D. - Standard Deviation

\*- statistically significant

## DISCUSSION

The study investigated effectiveness of a 4 week training using Xbox Kinect on psychosocial factors like fear of re-injury, pain catastrophizing level and self- efficacy in rehabilitation after ACLR. The results demonstrated a significant improvement in all the three parameters after the training. Hence, the hypothesis of the study was accepted. The study experienced 5 drop-outs, reasons being lost to follow up to the training program. The present study demonstrated a 13% reduction in the level of kinesiophobia after the Xbox Kinect training program. As described in previous literature, training with Xbox Kinect and other gaming systems improves the sense of stability, proprioception and self-reported knee functional level in competitive male athletes [10, 13, 14]. Kinesiophobia is affected by factors like strength, neuromuscular control and function. Erin H. Hartigan *et al.*; also confirmed that improvement in the dynamic stability and function had a beneficial effect on the kinesiophobia levels [5].

Kinesiophobia is also influenced by patient perception [5]. A low rate of perceived difficulty is found with Xbox intervention and hence it has been verified to be an enjoyable form of training [10, 14]. Studies also report an increase in the self-confidence level amongst the participants training with Xbox Kinect intervention [10, 14]. All the above factors would cause behavioural changes in the young participants, thus reducing the kinesiophobia levels. Another psychological factor which affects the participant's early return to sports is pain. Trevor A. Lentz *et al.*; reported in agreement that despite of the low pain intensity, the fear of pain can influence function after ACL reconstruction [11]. According to the Fear Avoidance Model, it is the interpretation of pain experience and not just the pain intensity that can lead to increase in fear and catastrophizing about pain [7].

This study evaluated pain using pain catastrophizing scale, pre and post VRT training with Xbox Kinect. And the study reported 56% reduction in the pain catastrophizing levels after the training. This

improvement in pain can be because of the fact that with Xbox training the participants did not pay much attention towards their impairments like pain, but on the outcomes of their movement in the projected environment [15]. Also Xbox Kinect training would facilitate normal movement patterns improving the dynamic stability and reducing pain. Xbox Kinect training showed more than 50 % reduction in the pain catastrophizing levels which can be considered as an extra-ordinary result contributing largely to the literature focusing on psychosocial component of rehabilitation after ACLR.

It should not be overlooked that Xbox Kinect training improved the self-efficacy levels by almost 29% in patients after ACLR. As self-efficacy was an important predictor for functional performance after operative procedure, it needs to be addressed to achieve the desired goal. There is a high association between the self-efficacy levels, knee pain and function [7-9]. High self-efficacy levels achieved by the participants in this study can be because of the recovery in pain and function after the Xbox Kinect training. The improvements in the pain catastrophizing and self-efficacy levels have been found to be more as compared to the kinesiophobia levels. This finding is in agreement of the study by Chmielewski *et al.*; which studied longitudinal changes in the above factors and concluded that kinesiophobia levels or the fear of injury improves slowly than pain catastrophizing and self-efficacy levels [7].

Everhart JS *et al.*; stated that the psychological factors are predictive of the outcomes after ACL reconstruction [16]. These factors are not so often evaluated and studied, may be due to the lack of research in guiding towards the selection of intervention for managing the psychosocial factors. Few other methods which have been found to be an effective treatment choice after ACL reconstruction are cognitive-behaviour methods and imagery. These interventions have improved self-confidence, self-efficacy and reduced the fear of re-injury [7]. Application of Xbox Kinect is also based on the same

principles. Along with the behavioural component discussed above, it let the participant work on its own pace regardless of the level [10]. This gives the player a sense of control and become an active participant in his own learning. Xbox Kinect provided specific feedbacks at the end of each game about performance and the result of their action. This constant feedback has been known to improve motor skill learning and motivation amongst the participants [10].

Considering the advantages of Xbox Kinect in improving psychosocial factors as described above, the study recommends an addition of this gaming system in the late phase of rehabilitation after ACLR. This would permit a smooth transition towards the advanced level of sports training after ACLR and would also help to increase the return to sports rate and reduce the risk of re-injury amongst the individuals. The strengths of the study were a prospective experimental design with homogenous subject population. However, there are few limitations to the study. The study did not include a control group for comparison and the sample size included was relatively smaller. However, a significant greater difference in the outcome measures warrants for further research in this area.

## CONCLUSION

Virtual reality training using Xbox Kinect system was effective in improving the psychosocial factors (kinesiophobia, pain catastrophizing and self-efficacy) in the late phase of rehabilitation after ACLR.

## REFERENCES

1. Smith MA, Smith WT, Kosko P. Anterior cruciate ligament tears: reconstruction and rehabilitation. *Orthop Nurs*. 2014 Jan-Feb; 33 (1):14-24.
2. S. van Grinsven, R. E. H. van Cingel, C. J. M. Holla, C. J. M. van Loon. Evidence-based rehabilitation following anterior cruciate ligament reconstruction *Knee Surg Sports Traumatol Arthrosc* (2010) 18:1128–1144
3. Wilk KE, Macrina LC, Cain EL, Dugas JR, Andrews JR. Recent advances in the rehabilitation of anterior cruciate ligament injuries. *J Orthop Sports Phys Ther*. 2012 Mar; 42(3):153-71.
4. Lentz TA, Tillman SM, Indelicato PA, Moser MW, George SZ, Chmielewski TL. Factors Associated With Function After Anterior Cruciate Ligament Reconstruction. *Sports Health*. 2009; 1(1):47-53.
5. Hartigan EH, Lynch AD, Logerstedt DS, Chmielewski TL, Snyder-Mackler L. Kinesiophobia after Anterior Cruciate Ligament Rupture and Reconstruction: Noncopers versus Potential Copers. *The Journal of orthopaedic and sports physical therapy*. 2013; 43(11):821-832.
6. McArdle S. Psychological rehabilitation from anterior cruciate ligament-medial collateral ligament reconstructive surgery: a case study. *Sports Health*. 2010 Jan; 2(1):73-7.
7. Chmielewski TL, Zeppieri G Jr, Lentz TA, Tillman SM, Moser MW, Indelicato PA, George SZ. Longitudinal changes in psychosocial factors and their association with knee pain and function after anterior cruciate ligament reconstruction. *Phys Ther*. 2011 Sep; 91(9):1355-66
8. Börsbo B, Gerdle B, Peolsson M. Impact of the interaction between self-efficacy, symptoms and catastrophising on disability, quality of life and health in with chronic pain patients. *Disabil Rehabil*. 2010; 32(17):1387-96.
9. Ayers DC, Franklin PD, Ring DC. The Role of Emotional Health in Functional Outcomes after Orthopaedic Surgery: Extending the Biopsychosocial Model to Orthopaedics: AOA Critical Issues. *The Journal of Bone and Joint Surgery American volume*. 2013; 95(21):e165.
10. Vernadakis N, Derri V, Tsitskari E, Antoniou P. The effect of Xbox Kinect intervention on balance ability for previously injured young competitive male athletes: a preliminary study. *Phys Ther Sport*. 2014 Aug; 15(3):148-55
11. Lentz TA, Zeppieri G Jr, George SZ, Tillman SM, Moser MW, Farmer KW, Chmielewski TL. Comparison of physical impairment, functional, and psychosocial measures based on fear of reinjury/lack of confidence and return-to-sport status after ACL reconstruction. *Am J Sports Med*. 2015 Feb; 43(2):345-53.
12. George SZ, Lentz TA, Zeppieri G, Lee D, Chmielewski TL. Analysis of shortened versions of the Tampa scale for kinesiophobia and pain catastrophizing scale for patients after anterior cruciate ligament reconstruction. *Clin J Pain*. 2012 Jan; 28(1):73-80.
13. Baltaci G, Harput G, Haksever B, Ulusoy B, Ozer H. Comparison between Nintendo Wii Fit and conventional rehabilitation on functional performance outcomes after hamstring anterior cruciate ligament reconstruction: prospective, randomized, controlled, double-blind clinical trial. *Knee Surg Sports Traumatol Arthrosc*. 2013 Apr; 21(4):880-7.
14. Rajaratnam BS, GuiKaian J, Lee Jialin K, Sweesin K, Sim Fenru S, Enting L, Ang Yihsia E, Keathwee N, Yunfeng S, Woo Yinghowe W, TeoSiaoting S. Does the Inclusion of Virtual Reality Games within Conventional Rehabilitation Enhance Balance

Retraining after a Recent Episode of Stroke?  
Rehabil Res Pract. 2013; 2013:649561.

15. Gokeler A, Bisschop M, Myer GD, Benjaminse A, Dijkstra PU, van Keeken HG, van Raay JJ, Burgerhof JG, Otten E. Immersive virtual reality improves movement patterns in patients after ACL reconstruction: implications for enhanced criteria-based return-to-sport rehabilitation. *Knee Surg Sports Traumatol Arthrosc.* 2016 Jul; 24(7):2280-6.
16. Everhart JS, Best TM, Flanigan DC. Psychological predictors of anterior cruciate ligament reconstruction outcomes: a systematic review. *Knee Surg Sports Traumatol Arthrosc.* 2015 Mar; 23(3):752-62.