

Comparison between the effect of non-immersive virtual reality training and conventional rehabilitation on balance in patients after ACL reconstruction – A Randomized Control Trial. : A Hypothesis

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Abstract

Background: Anterior cruciate ligament (ACL) injury is the most commonly seen knee ligament injury during sporting or recreational activities causing severe functional problems. Injury to ACL causes balance disorders due to proprioceptive dysfunction and mechanical instability at the knee. Altered neuromuscular control of the hip and knee joints and deficits in postural stability increases the risk of re-injury after ACL reconstruction. Therefore, enhancement of the neuromuscular control of the knee after ACL reconstruction is suggested by the prescription of balance and proprioceptive exercises which will reduce the risk of re-injury and lead to better results in terms of return to the functional activities. Different techniques for improving balance in these patients include the conventional balance training using devices like therabolt, wobble board etc. However, development of a more effective rehabilitation program which will help to address these deficiencies is required. New technology based technique such as non-immersive virtual reality using Microsoft Xbox Kinect has been proved as a reliable tool in improving balance in neurological cases such as stroke, cerebral palsy, etc. Hence, the objective of this study is to compare the effect of non-immersive virtual reality training and conventional rehabilitation on balance in patients after Anterior Cruciate Ligament(ACL)Reconstruction.

Hypothesis : Non-immersive virtual reality training would be more effective than the conventional rehabilitation for improving balance in patients after anterior cruciate ligament reconstruction

Clinical Importance : Training with Microsoft Kinect Xbox (XbK) will lead to better improvements in balance of the patients after ACL reconstruction. It will help in an early return to the functional activities or sports and will also reduce the risk of re-injury.

Future Research : Non- immersive virtual reality training can be given to the patients with other sport injuries for improving their balance.

Key words : Virtual reality training, Xbox, ACL reconstruction, Balance.

THESIS SUMMARY

Introduction

Anterior cruciate ligament (ACL) injury is the most commonly seen knee ligament injury during sporting or recreational activities causing severe functional problems [1]. Injury to ACL causes balance disorders due to proprioceptive dysfunction and mechanical

instability at the knee [2]. It further compromises the sport and recreational activities. Balance disorders are also seen because of decreased dynamic joint stability and disturbed functional movement patterns. Loss of mechanoreceptors in ACL injury causes altered neuromuscular control in the knee joint [3].

Some authors have evaluated deficits in the neuromuscular control after ACL reconstruction [4]. Altered neuromuscular control of the hip and knee joints and deficits in postural stability increases the risk of re-injury after ACL reconstruction [4].

Activities of daily living and recreational activities require coordinated neuromuscular control and sufficient strength in the muscles to perform the functional activities. Therefore, enhancement of the neuromuscular control of the knee after ACL reconstruction is suggested by the prescription of balance and proprioceptive exercises which will reduce the risk of re-injury and lead to better results in terms of return to the functional activities [5].

Development of a more effective rehabilitation program which will help to address these deficiencies is required. New technology-based technique of rehabilitation such as virtual reality training is a technology with opportunities to engage in multidimensional and multisensory virtual environments which appear to be similar to the real events [6]. This approach is based on the assumption that the virtual reality training will lead to corresponding improvement in the participant while performing in the real world. As it provides distraction during the movement tasks, it can be used to restore the joint motion [7]. Virtual reality training improves postural control, visuoperceptual processing, functional mobility and static and dynamic balance [8] [9].

Virtual reality training is of two types – Immersive and Non-Immersive. In immersive VR environments, the subjects are fully immersed in and interact with the environment [10]. In non-immersive VR environments, the interaction with the VR environment can occur by key-boards, mice and trackballs or may be enhanced by using 3D interaction devices [11]. However, the non-immersive VR is relatively inexpensive and easily accessible. It can be used as a home rehabilitation program and hence widely used in physical therapy.

Non-immersive virtual reality (VR) based rehabilitation has proved to be effective in improving balance in hemiparetic subjects [12]. VR training with Nintendo Wii gaming system has shown positive effects on balance adjustment in healthy individuals and also in knee ligament injuries [13].

Another example of this non-immersive virtual reality training is Microsoft Xbox Kinect (XbK). XbK is proved as a reliable tool in improving neuromuscular control in neurological cases such as stroke, cerebral palsy, etc. [14] [15] [16] [17]. A study was done in elderly population to evaluate the efficiency of two gaming systems such as XbK and Nintendo Wii over the traditional exercise program [18] [19]. The study revealed that the gaming systems were perceived as less strenuous and more enjoyable as compared to the traditional exercise programs. However, with XbK the energy expenditure is more as compared to the other gaming systems. Also, XbK provides a wider base thus increasing the freedom of movement for the individual performing the balance training [19].

Research has shown that an easy access to a facility or equipment is a major factor in compliance to an exercise program [6]. Since, XbK is an easily accessible and relatively inexpensive tool, it can be used for improving balance if proven to be effective [19]. A study has proved the effectiveness of XbK intervention on balance ability in previously injured young competitive athletes over the traditional exercise program [20]. Hence, it is important to compare the effect of non-immersive virtual reality training with the conventional rehabilitation in improving balance in patients after ACL reconstruction.

Hypothesis

Non-immersive virtual reality training has been proven to be effective in improving the balance in patients with neurological disorders [14] [15]. An example of this technology is Microsoft Kinect Xbox (XbK). XbK has been used to improve balance in athletes with chronic ankle instability [20]. Hence, it becomes essential to study the effect of non-immersive virtual reality training on balance and to compare it with the conventional rehabilitation so that it helps to improve the balance and functional status of the patients post ACL reconstruction and enhances an early return to the functional activities and sports, also reducing the risk of re-injury.

It is hypothesized that non-immersive virtual reality training would be more effective in improving balance as compared to the conventional rehabilitation in patients after ACL reconstruction.

The current research aims at comparing the effect of non-immersive virtual reality training and conventional rehabilitation on balance in patients after ACL reconstruction. A prospective randomized controlled trial will be performed after the approval from the institutional ethical committee. Study would be carried out at a tertiary health care center. The sampling will be done by chit method without replacement. A written and verbal consent will be taken from the participants after screening them for the inclusion and exclusion criteria. The subjects between the age group of 18-35 years, at 6 weeks post ACL reconstruction would be included. The subjects who have undergone ACL reconstruction with meniscus excision or grade I meniscus injury would be included. Subjects should have a 0 to 120-130 degrees of knee range of motion of the affected knee and the strength of the lower limb muscles should be at least from 3+ to 4 out of 5 on Manual Muscle Testing.

Subjects who have undergone ACL reconstruction with meniscus repair would be excluded from the study as the protocol after the surgery differs from that of the above mentioned inclusion criteria [21]. Also, subjects with fractures in the upper or lower extremities, collateral ligaments injury, traumatic cartilage injury, degenerative changes of the knee joint, injuries or surgical procedure to the opposite leg or any neurological disease would be excluded from the study.

Before commencing the physiotherapy rehabilitation, the participants shall be evaluated and demographic data will be collected from each patient that includes age, sex, and occupation, date of the surgery and details of the surgery. The knee range of motion by goniometer and strength of the lower limb on manual muscle testing shall be evaluated to satisfy the inclusion criteria. For the assessment of balance, Y- Balance test would be used [22]. To assess the functional status and activity level of the knee, Modified Lysholm Knee Score and Tegner Activity Level will be used respectively [23].

Subjects will be assessed pre-intervention and after 4 weeks of the training program. The participants will be randomly allocated into two groups- Group A (non-immersive virtual reality training) and Group B (conventional rehabilitation). In group A, participants will be given virtual reality training by the means of Microsoft Kinect Xbox (XbK) and the games included in the study would be River Rush, 20,000 Leaks, Reflex Ridge, Rally Ball and Space Pop [20]. Progression would be in the form of increase in the difficulty level of the game, for example, basic, intermediate and advanced levels. Each game incorporates different static and dynamic postures which would help in improving the balance.

In group B, the participants will be given conventional balance exercises which would include single leg standing on floor and on

therabolt and standing on a wobble board [5]. Progression would be in the form of eyes closed while balancing on single leg and ball catch and throws on wobble board.

In both the groups, participants would be given strengthening exercises for quadriceps and hamstring muscles. The progression would be based on the De Lorme and Watkins regimen for progressive resistance training.

After each treatment session in both groups, participants shall be asked for the rate of perceived exertion in order to match the exercise intensity given in both the groups. The Borg category-ratio 10 will be used to assess RPE [24]. In the initial week, the expected RPE in both groups is 3 (moderate). In the 2nd week, the expected RPE in both groups is 4 (somewhat hard) followed by 5 (hard) and 7 (very hard) in the 3rd and 4th week respectively.

Post intervention, assessment for balance and functional status of the knee shall be done.

The collected data will be statistically analyzed. The within group analysis for Y- Balance test will be done by paired t-test and the between group analysis will be done by unpaired t-test.

The within group analysis for Lysholm knee score-Tegner activity scale will be done by Wilcoxon sign rank test and between group analysis will be done by Mann-Whitney U test.

Discussion

Balance and proprioceptive training is an integral part of rehabilitation after ACL reconstruction. Balance training after ACL reconstruction has also shown reduction in the risk of re-injury in the patients [4]. Over the years, the neuromuscular training has been given by conventional balance exercises such as single leg standing, standing on wobble board etc. However, a new rehabilitative technique like non-immersive virtual reality training using the Microsoft Xbox Kinect (XbK) has been proven to be effective in improving balance and level of functional activity in geriatric patients and also in neurological cases.

A research studied the effect of Xbox intervention on balance ability of competitive athletes with chronic ankle instability [20]. It was proved that XbK intervention is a valuable, feasible and pleasant method to improve the balance ability in those athletes. In a study on patients with ACL reconstruction, a different mode of non-immersive virtual reality training like Wii Fit Balance Board was used to improve visual-perceptual processing, co-ordination, proprioception and functional mobility [13]. The results showed that the Wii Fit Balance Board training had similar effects on all of the above parameters.

In the current research, the balance program used in the XbK intervention would be task driven and would require problem solving. These features of the training have been shown to promote behavioral changes as well as the further changes in the physical abilities in young adults [20].

The improvements in the balance could be attributed to the fact that the Xbox intervention would allow the user to be an active participant in his own learning. Research has shown that for the acquisition of specific motor skills such as balance, the game should encourage intentional learning and should explicitly present and let the player sense the targeted skills through appropriate simulation [20].

The conventional balance training program leads to poor engagement and lack of interest by the patients due to repetitive practice of the same exercises [12]. Studies have shown that Xbox intervention induces a feeling of competitiveness, achievement and

interest in the patients, which in turn helps in boosting the self-confidence of these patients [20].

Another reason for the improvement in balance in the Xbox intervention group would be the specificity and frequency of the feedback given by the system about the knowledge of their performance and the knowledge of the result of their actions. Augmented feedback in the form of either knowledge of performance or knowledge of results promotes motor skill learning and also motivates the player [12].

The Xbox adventure games would involve different postures and activities like squatting, side stepping, weight shifting, etc. These games would put greater demands and challenges on the neuromuscular system. Xbox adventure simulation games are effective in favoring the acquisition of the balance ability and their transfer to the real world contexts under certain conditions [20].

The Xbox adventure games would also provide an immediate visual feedback of their performance and would empower them with a sense of control over their recovery as they would be engaged in more of a self-practice. Virtual reality training would also provide an additional element of fun and competitiveness which the conventional balance program lacks.

In a study done on effect of virtual reality training on balance in older women suggests that virtual reality balance games retrains one's Centre of Pressure in different directions, ranges and speeds frequently and elicits effective ankle and hip postural control strategies to maintain functional mobility [12]. So, the Xbox intervention would also lead to an increase in the functional status of the patient by improving the functional mobility of the knee.

Also, virtual reality training would provide an additional wider base for the patient to perform the exercises as compared to the conventional balance training program which would assist in providing more freedom of movement [19].

Thus, the study hypothesis states that non-immersive virtual reality training would be more effective in improving balance in patients after ACL reconstruction than the conventional rehabilitation program.

Clinical Importance

The use of non-immersive virtual reality training by using Microsoft Kinect Xbox would be effective in improving the balance and the functional status of the patients after ACL reconstruction surgery more efficiently as compared to the conventional balance training program. It will help the patients in an early return to the functional activities or sport activities. Increase in balance will also minimize the risk of re-injury in these patients.

Future direction

Effectiveness of non-immersive virtual reality training should also be determined in other sport injuries and also in competitive athletes to aid in their rehabilitation.

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