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Research Article

The Multimodal Exercises on Physical, Functional, Agility, and Perturbation for Post- ACL Reconstruction Among Athlete

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Abstract: The anterior cruciate ligament (ACL) is one of the key ligaments that help stabilize our knee. Anterior cruciate ligament reconstruction (ACLR) is one of the most commonly performed orthopaedic surgeries to restore joint stability. Professional athletes may aim to return to play within 6 to 9 months safely. The multimodal approach is a condition that helps prevent injury recurrence. The study aims to determine the multimodal approach for ACL rehabilitation after reconstruction and the effect on physical, functional, agility, and perturbation for sports persons. The experimental study included 30 subjects randomly allocated into two groups group A(n=15) received multimodal training exercises, and group B(n=15) received standardized ACLR protocol training exercises**.** The outcome measure was International Knee Documentation Committee, Berg Balance Scale, Single Hop Test, and Agility-t-Test**.** Statistical analysis was done using both paired and unpaired "t" tests, which showed more significant improvement in group A. This study result shows that the Multimodal exercises along with standardized ACL rehabilitation protocol Group A show effective in improving the physical, functional, agility, and perturbation activities than the standardized ACLR protocol exercise alone Group B for sports persons who underwent ACL reconstruction after four weeks of interventions.

Keywords: *Multimodal training exercise, Standardized Knee Protocol training, Perturbation training, Berg Balance, Agility-t-Test.*

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1. INTRODUCTION

The anterior cruciate ligament is a major ligament out of eleven ligaments in the knee joint. They are termed as cruciate because it's cross each other. ACL functions as the primary restraint against the anterior translation of the tibia about the femur and provides rotational stability [1,2] The origin is from the anterior part of the intercondylar of the tibia. It extends superiorly, posteriorly, and laterally and is composed of two major fibre bundle, which provides approximately 85% of the total restraining force of anterior translation. Antero-medial and posterolateral bundles are also intermediate bundles.[3] This structure also becomes tightened while pulling with the knee in extension, medial, and lateral rotation.[4 - 6] Although ligament injury accounts for nearly 40% of problems in the anterior cruciate ligament and it constitutes 50% of all knee ligament injuries.[7- 9] Sports involving running activities such as football, basketball, and baseball and other contact sports such as rugby contribute to the major cause of these injuries.[10,11] Anterior cruciate ligament reconstruction(ACLR) is one of the most commonly performed orthopaedic surgeries to restore joint stability after an ACL tear, with up to 1,75,000 procedures each year in the United States Anterior cruciate ligament injury most often occurs in young, active individuals, and the majority of injuries occur through noncontact mechanisms.[12,13] In a sports population, the percentage of surgical reconstruction is 76.6%.[14] For example, France recorded 41,000 anterior cruciate ligament reconstruction operations in 2012, representing a real concern for public health and a high economic cost. [15-18] In the united states, ACL injuries occur at least once in 3500 individual[s] every year and approximately 1,25,000 to 2,00,000 ACL reconstructions are performed annually. Often, despite ACL reconstruction, asymmetries persist in both lower limbs. These asymmetries are responsible for walking disorders, which appear from the first postoperative month to 6 months or even a few years after the surgery. Only 65% of operated patients resume their sport simultaneously; for the rest, 24% continue their sport at a lower level, and 11% completely stop practising sport.[19-22] Returning to sport over activity too soon poses a substantial risk of reinjures. Professional athletes may aim to produce to play within 6 to 9 months safely. However, many protocols often cite a rehabilitation period of closer to 12 months to reduce the risk of reinjury [23] The amount of time taken for rehabilitating the individuals will vary based on intrinsic factors such as their fitness level before injury, coordination, genetics, and motivation. Extrinsic factors such as attending a structured rehabilitation program, occupational demands, and socioeconomic level may influence prognosis.[24] The period of rehabilitation protocol also varies for everyone based on their age, previous activity levels, who underwent surgery, concurrent/prior injuries, and motivation. ACL recovery rehabilitation may include strengthening exercises for one's leg, hip/pelvis, and core region and correcting training errors through proprioceptive and plyometric exercises for pivoting, jumping, and landing. Initially, it is important to rest the limb, apply ice around the joint, compress the joint, and elevate the limb.[25] Typically, rehabilitation starts with the restoration of motion within the knee and other associated tissues, including knee extension exercises with possible help from knee extension machines. After the range of motion is back, strengthening of the muscles usually comes next. For example, isokinetic exercises may be incorporated, hamstring strengthening exercises, knee strengthening exercises, etc. Finally, the last step would be restoring the injured region's function through daily functional activities and sport-specific activities.[26] In the late stages of rehabilitation, the goals are to reintroduce sport/activity-specific training. At this stage, it is encouraged to increase strength and move towards more dynamic activities. Other specific dynamic movements relevant to the patient may be a part of the rehabilitation program.[27] Exercises such as lateral bounding on and from a single leg may help neuromuscular control and confidence with sport-specific activities. These activities should improve strength, coordination, and confidence back to their previous activities. The total time for rehabilitation will exceed 24 weeks; however, after this stage, patients should be able to continue with rehabilitation independently as many of their day-to-day functional activities should be restored at this stage.[28] Multimodal exercises are the group of exercises that includes knee strengthening exercise, balance exercise, and flexibility exercise. The main part of the multimodal exercise program is the destination in about minutes. This includes tasks for strength (50%), balance (30%) and flexibility (20%). In addition, knee protocol exercises also improve knee executive functions. This task is carried out with moderate to maximal intensity. For ACL reconstruction, rehabilitation was formed on the strength and flexibility of a sportsperson. However, the recent approaches, in addition, return to play rates are low and second injury rates are highest among this population [21] 1. Therefore, this study is to implement the multimodal approach for ACL rehabilitation after reconstruction and find out the effect on physical, functional, agility, and perturbation for sports persons. Hence, the therapeutic approaches of the knee strengthening exercise using ACL protocol exercise have a positive effect on improving knee function, balance, and agility. The effect of ACL protocol exercise on the knee has been investigated in some studies. Similarly, multimodality exercise, in addition to the protocol exercise, significantly improved knee function and balance agility. However, no study has proven the effectiveness of multimodal ex's on physical, functional, agility, and perturbation for a sports person who underwent ACL reconstruction.

2. MATERIALS AND METHODS

The study was conducted according to the ethics guidelines and principles of the Declaration of the ethical committee from Sri Venkateshwaraa College of physiotherapy (1308svcopt/22). All the participants were included informed consent form about the purpose and method of research and signed to participate in the study. The Experimental study was carried out in an academic physiotherapy centre and Sports clubs in Pondicherry and included patients of the centre in the years 2020–2021. The experimental study comprised two groups. Group A (N=15) and Group B (N=15) consist of patients with ACL and are matched with patients in terms of gender, age, body mass, and body weight. The initial sample of patients who started rehabilitation procedures in the academic centre was 50. Participants were recruited to particular study groups based on the following inclusion criteria (Table 1) and excluded from the study if they met at least one of the exclusion criteria.

Table 1: Selection Criteria

INCLUSION	EXCLUSION
Subjects who attended regular rehab protocol before ACL reconstruction	Any other surgical procedures on the lower extremity within past six months
Both male and female	History of a neurological disorder that affects lower extremity function
Subjects aged between 18-30	Discontinued the post-surgical rehab due to any reason.

3. ORTHOPAEDIC EXAMINATION AND MEASURING TOOLS

The participants after ACLR were included or excluded from the study based on the orthopaedics examination and history. Functional activities for knee (IKDC), Perturbation (Berg Balance Scale), physical activities for knee (Hop Test), and Agility (Agility T-test).

4. PROCEDURE

Patients who fulfilled the inclusion criteria were included in the study. The benefit of the study and treatment intervention was explained to the patient, and written informed consent was taken. The subject was assessed using inch tape and a stopwatch for the agility test, hop test and questionnaire, and evaluation form for balance, pain, and functional activities. Here ACL protocol is used as conventional therapy for both groups. The patients were randomly allocated into two groups consisting of 15 each.

4.1. *Experimental Group A*

Multimodal exercise with 24th week ACL protocol exercise given for three sets – 10 repetitions for alternate days for eight weeks.

4.1.1. Control Group B

Standardized ACL protocol 24th-week exercise must be given for three sets – 10 repetitions for the alternate eight-week days.The subjects were assessed by using multimodal exercise. Each task was explained and demonstrated to the subject, and they attended the day before the training. All participants received approximately 45-minutes training sessions three times a week for eight weeks. The participants were instructed to spend 5 minutes on each task.

4.1.2. A. Multimodal Exercise Intervention

Knee flexibility stretching exercises (12 minutes) includes[31 32,33.]

Table 2: Multimodal Knee Flexibility Exercises

MULTIMODAL KNEE FLEXIBILITY EXERCISES	PROCEDURE	REPETITION
1. Straight leg raises	The patient was positioned Supine, lying with a cushion under the back. The therapist Stands beside the patient; the testing limb is extended while the contralateral limb is in a flexed position. Contract the quadriceps and slowly lift the extended leg upwards to the height of your contra lateral bent knee. Hold for 5 seconds, and then lower down slowly. (Fig 1)	Repetitions: 2 -3 sets of 10 repetitions for each leg.
2. calf stretch	The patient is positioned in a standing position by facing a wall. The therapist Stands beside the patient and asks the patient to Place the hands on the wall. Extend one leg backwards while the other knee is slightly bent forward. Both the heels must be flat on the ground. Lean-to stretches and holds for 30 seconds. (Fig 2)	Repetitions: Twice for both legs
3. Quadriceps stretch	The patient was standing at the level of shoulder-width apart next to the wall for support. The therapist asks the patient to Bend one knee and grabs the ankle. Gently push it towards your gluteus as far as you can. Hold for 30 seconds. (Fig 3)	Repetitions: Two times for both legs
4. Hamstring stretch	The patient was positioned in a supine with the extension of both legs. The therapist asks the patient to Lift one leg off the floor towards the chest until you feel a slight stretch. Hold for 30 seconds. (Fig 4)	Repetitions: two times on each side.

Fig 1: Straight leg raises

Fig 2: calf stretch

Fig 3: Quadriceps stretch

Fig 4: Hamstring stretch

Table 3: Knee Strengthening Exercises : (12 minutes)

KNEE STRENGTHENING EXERCISES : (12 minutes)	PROCEDURE	REPETITION
1. Step up-down exercise	The patient was positioned in a standing position on the steps. Hold onto a chair or wall for support. The therapist asks the patient to Place one foot on the step. Step up the other leg, touch the step and drop back down. Stand on both feet on the step. One foot on the step while the other gently taps down and back to position. (Fig 5)	**Repetitions:** 3 sets of 5 repetitions.
2. Single-leg wall slide exercise	The patient was standing on a single leg with the back and buttock touching the wall. Place both the foot 6 inches from the wall. The therapist asks the patient to lower the body by bending the knees and sliding down the wall tills 45 deg. Hold for 5 seconds and return to starting position.	**Repetitions:** 3 sets of 5 repetitions.
3.Single-leg squat exercise	The patient was positioned by standing on one leg with chair support at the back. The therapist asks the patient to Reach her hands forward for balance. Bend your waist as you descend, lowering the buttock towards the chair. The head must be over the feet. Hold for 10 secs. Fig 6	**Repetitions:** 3 sets of 5 repetitions.
4.Double-leg plyometric jumping drills	The patient was positioned by standing with knees bent position. The therapist as the patient to jump in a lateral direction, landing on a footstool with knees in a flexed position. (Fig 7)	**Repetitions:** 3 sets with 30-60seconds intervals.
5.Lateral stepping with resistance bands	Patient positioned the patient is standing a foot apart from the shoulder-width position. Therapists ask the patient to tightly wrap a resistance band around the distal femur and hold it in position. Slowly step to the side outside your shoulder width and return to starting position. (Fig 8)	**Repetitions:** 3 sets of 5 repetitions.

Fig 5: Step up-down exercise

Fig 6: Single leg squat

Fig 7: Double leg plyometric

Fig 8: Lateral stepping with resistance bands

Table 4: Knee Balancing Exercise (12 minutes)	
1.Banded tri planar toe taps	The patient was positioned in a standing position. The therapist asks the patient to Stand in front of the therapist. Put a resistance band on the lower thighs just above the knees. Stand on a single leg and quarter squat the knee. Slowly tap the leg forward, to the side, and backward. Repetition: 10-20 repetitions.
2.Squat on a tilt board	The patient is standing on the tilt board with the hip distance apart. The therapist Stands beside the patient. Ask the patient to squat on the tilt board 30degree. balance the position for 30 seconds. Repetition: 5-10 repetitions (fig 9)
3.Single-leg stance on foam	The patient positioned the patient with a standing position on the foam. Therapists ask the patient to Stand on a single leg on the foam with the other leg bent. Focus on standing upright without leaning in any direction for 1-2 minutes. Repetition: 5-10 repetitions

Fig 9: Squat on a tilt board

4.1.3. B. Control Group

SIX MONTHS STANDARD ACL PROTOCOL by MOON guidelines[34].

5. RESULTS

The data obtained from the outcome measures pre and post-intervention were analyzed statistically. The values in Table (5) show the difference between groups A & B with the mean difference (MD) and Standard deviation (SD) for IKDC are 20.487± 1.894 and 17.387± 1.686 (chart 1.2), Berg Balance is 5.024 ± 0.877 and 2.733± 0.588 (chart 1.1), SINGLE HOP TEST are 12.85 ± 1.419 and 8.99.65± 1.246 (chart1.3) and AGILITY-T TEST are 2.53 ± 0.287, and 1.62± 0.22 (chart 1.4) were figured. Therefore, the above analysis shows that Group A is more significant than Group B with the significance of 'p value'< 0.0001., Hence there is an improvement in physical, functional, agility, and perturbation performance in group A (Multimodal exercises) than in group B (Standard protocol exercises) for ACL reconstruction sports persons.

Table 5: Shows the Mean value, standard deviation, 't-test and 'p' values.

	SINGLE HOP TEST			
	MEAN DIFFERENCE	SD	t-VALUE	p-VALUE
Group A	12.85	1.419		
Group B	8.99	1.246	1.2759	<0.05
	AGILITY T-TEST			
	MEAN DIFFERENCE	SD	t-VALUE	p-VALUE
Group A	2.53	0.287		
			3.298	<0.05
Group B	1.62	0.220		
	MEAN DIFFERENCE	SD	t-VALUE	p-VALUE
	BERG BALANCE TEST			
Group A	5.024	0.877		
			2.0978	<0.05
Group B	2.733	0.588		
IKDC	MEAN DIFFERENCE	SD	t-VALUE	p- VALUE
Group A	20.487	1.894	3.358	<0.05
Group B	17.387	1.686		

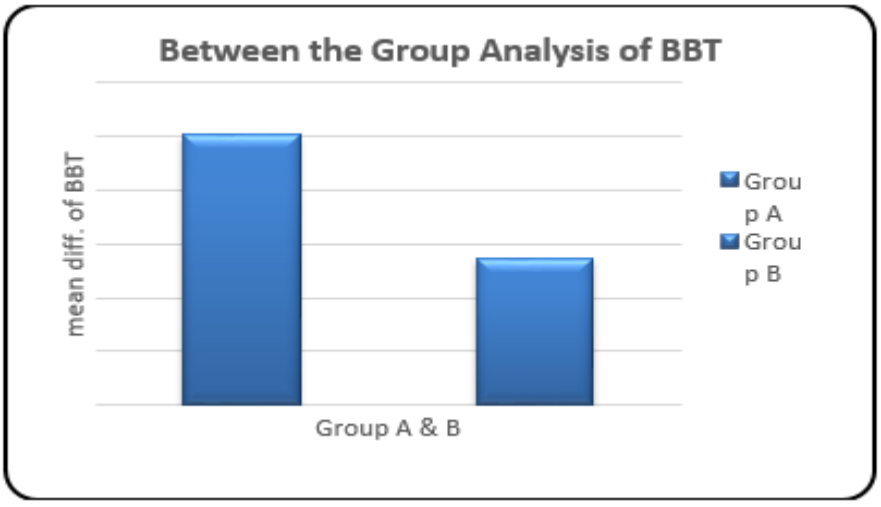

Chart 1.1: Between the Group Analysis of BBT

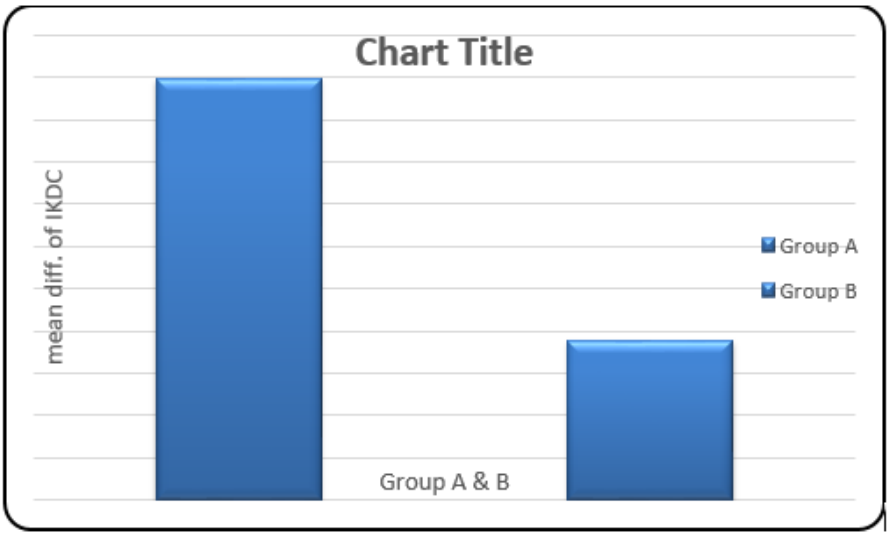

Chart 1.2 Between the Group Analysis of IKDC

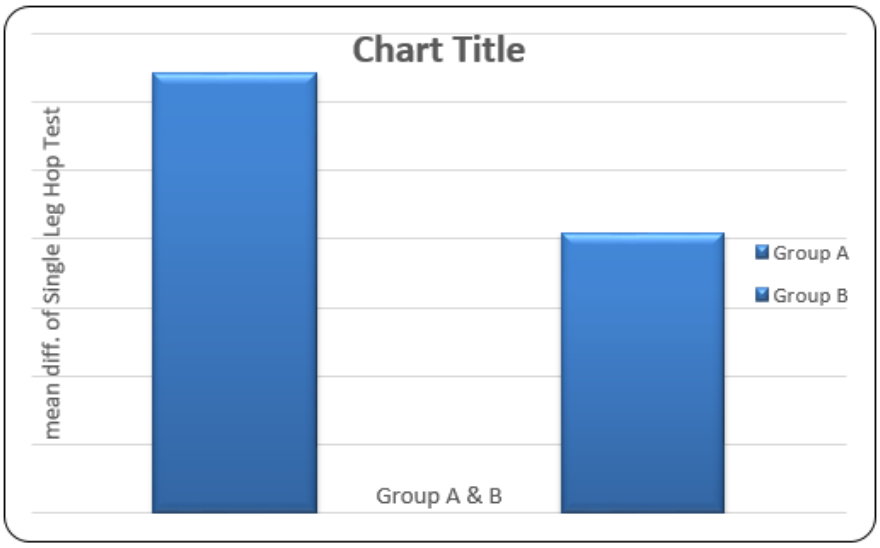

Chart 1.3 Between the Group Analysis of Single Leg Hop Test

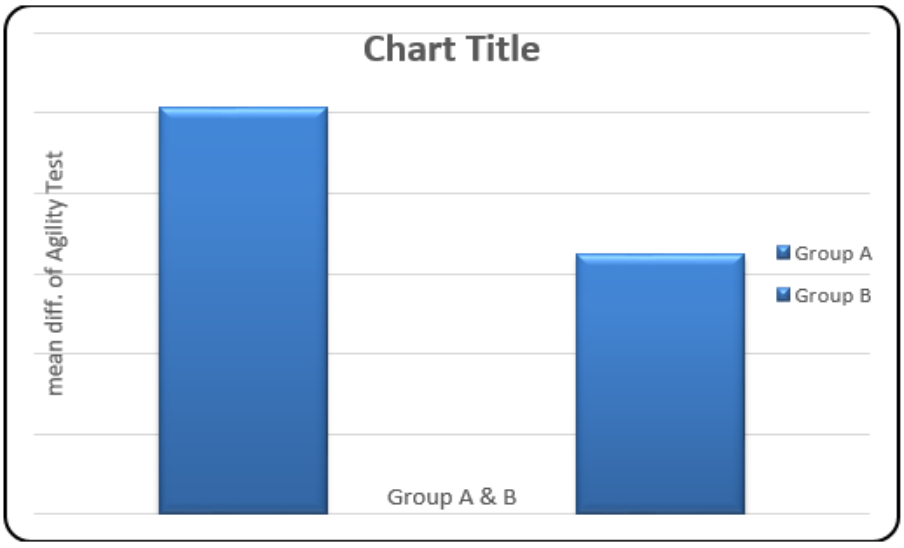

Chart 1.4 Between the Group Analysis of Agility Test

6. DISCUSSION

This study evaluated the efficacy of Multimodal exercise, standardized knee protocol exercise and only standardized knee protocol exercise in patients with ACL reconstruction. This study focuses on strengthening the knee joint and around attachment muscles, thereby correcting the knee alteration in improving the functional activities of ACL reconstruction sports persons. This study determines which group of exercises improves knee physical, functional, agility, and

perturbation performance after three weeks of follow-up. So to improve knee activities, two different kinds of exercise training were given to two groups (A, B). According to one systematic review and meta-analysis, younger age (Age below 25) and resumption of high levels of activity are significant risk factors for secondary ACL injury. These data suggest that nearly one in every four young athletic patients who sustain an ACL injury and return to high-risk sports will suffer another ACL injury later in their career.[35] Based on the view of researchers, understanding the characteristics of physical activity has also been proposed as a means of assisting young adults in improving their health through more tailored interventions.[36] ACL reinjury following anterior cruciate ligament reconstruction (ACLR) occurs more commonly in athletes than in the general population. It is critical to identify high-risk athletes in a group of ACLR participants to improve outcomes after ACLR and return to sport (RTS).[37] Alterations in neuromuscular control of the hip and knee during a dynamic landing task and postural stability deficits following ACLR are risk factors for anterior cruciate ligament injury recurrence after an athlete is given the all-clear to resume sports.[38] The frontal plane knee and hip range of motion during single-leg landing biomechanics are related to greater psychological preparedness for the affected limb to return to sport. In any other way, the sagittal or frontal plane sing-leg biomechanics of the involved or uninvolved limbs were not associated with psychological preparation.[39] Researchers also found that level 1 athletes had high overall RTP rates, lower reinjury rates with patellar tendon grafts, and no effect of time to RTP on a second ACL injury after a 2-year follow-up. [40] Many athletes returned to sports, but one in every five had knee reinjures. The ACL graft was more likely to be reinjured in male patients. Before RTS, testing for knee stability, strength, neuromuscular control, agility, and psychological measures remains critical in young athletes.[41] A previous study found that two physical training sessions per week (4 hours per week) of intense training are at least comparable and even more effective (for some functional performances) than three sessions per week (6 hours per week) of relatively low-intensity training from 4 to 6 months post-ACLR. This may free up time for the gradual introduction of sport-specific technical training.[42] There is currently no gold standard for rehabilitation following ACL reconstruction, emphasizing the importance of rigorous studies evaluating the best modalities for athlete rehabilitation and determining the efficacy of new tools for improving therapy, such as blood flow restriction therapy and neuromuscular electrical stimulation.[43] According to clinical experience, a renewed emphasis on objective, criterion-based milestones may maximize the ability to return to preinjury levels of athletic function. The current literature, combined with the clinical outcome described in the case, suggests that multimodal care, which includes progressive exercise, vibration therapy, NMES, and LLLT, may be more beneficial than any single modality alone. More research is needed to investigate the efficacy and associations of these modalities in a larger study population.[44] Across the literature, the methods used to determine this in treating athletes who have recently undergone anterior cruciate ligament (ACL) reconstruction may vary. Some authors report primarily using time-based criteria to inform decision-making, whereas others advocate for physical measures and kinematic testing. Aspects of both functional and cognitive testing have also been shown to be useful in previous studies and, as a result, modern proposed methods of determining an athlete's readiness for sport have been incorporated. [45] A study aimed the returning to sport after ACL reconstruction in physically active individuals using various outcome measures for function, physical, and fear in which 93 participants included the majority [69.9%]. The study found that even more than half [61.3%], only 29 participants are at the same level of the sport before the injury. The pain and fear of pain was the most frequent reason for delaying or not returning to the sport. Also physical and functional status of players also influenced the return to the sport[46]. Fear of reinjury following surgery may be related to the timing of surgery following injury, and the level of sport returned to by athletes.[48] A case report of a 16-year male athlete with right ACL rapture and LCL sprain was selected for a multimodal approach in rehabilitation of the pre-operative phase. The subject had a grade 3 ACL tear and was administered with a multimodal approach including TENS, whole-body vibration combined with resistance exercises was given TENS pre-week for 12 days. The study found that vibratory stimulus combined with resistance training improves neuromuscular function by realigning the muscle fibres, improving strength power and proprioception, and reducing pain. The multimodal approach was incorporated successfully into the management plane in the study[47]. A study proves that high-intensity multimodal training is highly recommended as part of the annual training program for elite handball players[49]. In this study, the Multimodal training exercise has gained popularity to gain greater physical, functional, agility, and perturbation by muscular activation. It has been shown to improve knee flexibility, strengthening, and balance. Flexibility training reduces tightness in the muscles around the knee to increase flexible mobility and make it easier to move in daily activities. The strengthening exercises develop an increased range of motion and reduce the risk of pain and injury. It also offloads unwanted stressors on the knee joint by improving shock absorption through enhanced muscle strength. And balancing training increases dynamic stability, Proprioceptive functions, and improved postural stability of the knee joint, which enhances neuromotor recruitment, thus enhancing muscle strength such as primary muscles of the quadriceps, hamstring, and vastus lateralis and vastus medialis muscles. From the above discussion, this study states that the experimental group treated with multimodal exercise training showed significantly improved knee physical, functional, agility, and perturbation more than the control group treated with standardized knee ACLR protocol training.

7. CONCLUSION

This study concludes that the Multimodal exercises along with the standardized ACL rehabilitation protocol (GROUP A - EXPERIMENTAL) are more effective in improving the physical, functional, agility, and perturbation activities than the standardized ACLR protocol exercise alone (GROUP B - CONTROL) after four weeks of interventions for athletes who underwent ACL reconstruction.

8. AUTHORS CONTRIBUTION STATEMENT

Anand babu kaliyaperumal conceptualized, designed and gathered data. Paulraj manika velu analyzed babu Subbiah and gave these data and inputs. All authors discussed the methodology and results and contributed to the final manuscript.

9. CONFLICT OF INTEREST

Conflict of interest declared none.

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