Innovations

Efficacy of Therapeutic Exercise Versus Muscle Energy Technique in the Rehabilitation of Anterior Cruciate Ligament Reconstruction of Knee: A Pilot Study

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Abstract

The Purpose of the Article: *To compare the efficacy of therapeutic exercise versus muscle energy technique in rehabilitating improved ROM, decreased pain, and improved quality of life of the Anterior Cruciate ligament reconstruction of the knee.* ***Materials and Methods:*** *In this study total of 12 patients with post-ACL reconstruction will be divided into two groups, one group will receive therapeutic exercise with high-frequency TENS and the other will receive muscle energy technique with high-frequency TENS. The treatment will be given for 5 weekly sessions for five weeks and a one-monthfollow-up. The assessment will be done on 1st day of treatment, the second assessment of 3rdweek of treatment, and 5th assessment at the end of treatment.* ***Result****: There was a positive correlation between Group A and Group B NPRS (r^2=0.968), Goniometer (r^2=0.9964) and KOOS-Pain(r^2=0.8014), Symptom(r^2=0.968), ADL (r^2=0.9441), Sports & Recreation (r^2=0.9593) and quality of life (r^2=0.9576).* ***Conclusion****: This study showed that therapeutic exercise with high-frequency TENS has a better effect than the muscle energy technique with High-frequency TENS, on*

improving pain, ROM, and quality of life in patients after ACL reconstruction of the knee.

***Keywords**: Therapeutic Exercise, Muscle Energy Techniques (MET), Anterior Cruciate Ligament (ACL), Reconstruction, Rehabilitation, knee*

Introduction

ACL injuries sustained in sports or leisure activities are frequent worldwide and have a substantial financial impact on society due to lost productivity and increased medical expenses[1-3]. Frequently occurring injuries among young athletes is an anterior cruciate ligament (ACL) injury [4]. Meniscal damage, tibiofemoral instability, and worse functional outcomes have all been linked to ACL injuries [4-7]. Ligamentous repair has the potential to mitigate the risk of persistent instability, enhance functional results, and lower the incidence of degenerative joint disease [11-14]. After surgery, ACL injuries to the contralateral knee occur more frequently in women than in males [15]. In the United States, ACL reconstruction is the preferred treatment for most patients with ACL injuries. Restoring joint stability is the main objective of ACL repair, enabling patients to resume their prior degree of function.[16].

The osteopathic muscle energy technique relaxes and stretches a muscle through autogenic or reciprocal inhibition by using the muscle's energy as mild isometric contractions [17]. Although manual therapists and practitioners typically employ muscular energy techniques (MET), there is a paucity of research endorsing and validating the technique's application, as well as ideas elaborating on the technique's effectiveness.Numerous studies have looked at the benefits of contract-relax techniques (like MET) on the flexibility of the hamstrings and have shown that these techniques increase muscular flexibility[18,19].

This study evaluates the effects of therapeutic exercise and muscle energy techniques on pain, ROM, and quality of life in the post-surgery ACL reconstruction of the knee.

Aim and objective: This study aims to compare the efficacy of therapeutic exercise versusmuscle energy in improving range of motion, decreasing pain, and improving quality of life in the rehabilitation of ACL reconstruction of the knee

Materials and Methodology

Material Required:

1. NPRS
2. Goniometer
3. KOOS

Methodology

Study design: Participants will be chosen from the orthopedic department of the NIMS Hospital, Rajasthan, Jaipur, following permission from the NIMS, Jaipur, Rajasthan. Before enrollment, participants will get an explanation of the study's goals and methodology. They will provide their signature on the written consent form.

Study setting: Department of Orthopedic, NIMS Rajasthan, Jaipur.

Study Duration: Five weeks and one-month follow-up
Study Population: Post-surgical ACL Reconstruction of the knee
Sample size: n = 12 patients (6 in each group)
Study design: Pilot study
Study type: Comparative Study
Randomization: Simple random sampling
Sample size: n = 12 patients

Inclusion criteria: The individuals within 18-40 years, male and female, diagnosed with ACL injury and have undergone the anterior cruciate ligament reconstruction (2^{nd} day onwards)

Exclusion criteria: The individual above 40 years of age and those withPrevious meniscus rupture requiring repair, Evidence of degenerative disease on radiology imaging, and Superficial sensory deficit.

Participant timeline: Every patient enrolled in the trial must finish their five weeks of therapy.Assessments will be conducted both during the last session and at baseline.

Dependent variable: NPRS, Range of motion, KOOS
Independent variable: Therapeutic exercise, Muscle energy technique.

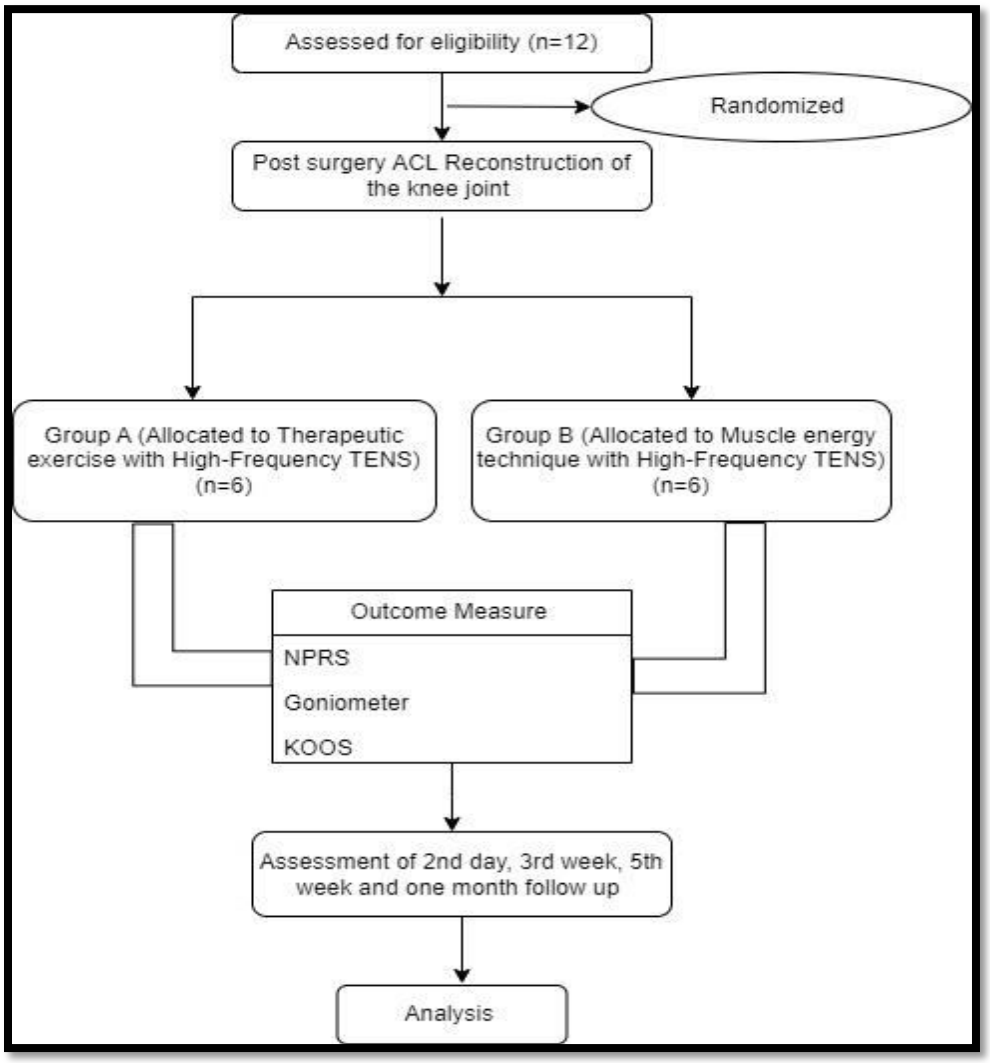

Figure 1. Flow chart of the methodology adopted for the Pilot Study

Study Procedure:

Group A: **Therapeutic Exercisewith Transcutaneous Electrical Nerve Stimulation (TENS)**:

An exercise program for rehabilitation was created in the manner described below to guarantee the security and efficacy of rehabilitation exercises. [20].

Table 1: Therapeutic exercise after ACL reconstruction of the knee

S.No	Phase	Therapeutics Exercise
1.	Phase 1 (2-7 days)	• Passive knee extension (10 sec./10 times/3–5 sets) • Ankle toe movement (10 times/5 sets) • Active and Passive knee joint flexion (10 sec./10 times/5–10 sets)

		• Straight leg Raise (10 times/5 sets) • Quadriceps Isometric (10 sec./10 times/3–5 sets) • Stretching of Hamstring (10 sec./5–10 sets) • Standing hamstring curl (10 times/3–5 sets) • Mini squat (10 times/2–3 sets)
2.	Phase 2 (2- 3 weeks)	• All exercises from Phase 1 • Leg press (10 times/2–3 sets/0–30°/ weight bearing) • Leg extension (10 times/2–3 sets/90°–40°) • Half squat 0–40° (10 times/3–5 sets) • Hamstring curl in a prone position (10 times/3–5 sets) • Cycling (10 minutes) • Patella mobilization (5 minutes) **3rd week** • All exercises from Phase 1 and Week 2 • Passive ROM exercise 0–115° - Cycling (5–10 minutes) • Leg extension emphasizing extending exercises (40°–90°) (10 times/3–5 sets) • Side stair climbing (10 times/2–3 sets) • Front stair climbing (10 times/2–3 sets) • Proprioceptive sense training (5 minutes)
3.	Phase 3 (4 – 5 weeks)	• All exercises from Phase 1 and 2 • Wall squat (0–30°) (10 times/3–5 sets) • Calf raise (15 times/3–5 sets) • **5th Week** • Walking 10–20 minutes 10th –12th weeks • Balancing exercise (tilt board) (5–10 minutes) • Isokinetic exercises 90°–40° (120°/s) (10 times/5 sets)

Group B:Muscle Energy Technique (MET) + Transcutaneous Electrical Nerve Stimulation (TENS):

Post-Isometric Relaxing Technique

Post-isometric relaxing technique was used to apply MET.The subject was resting supinely with his leg extended. His hip was passively flexed until the examiner detected tightness and the subject reported a moderate stretching sensation.The subject performed a moderate (about 35–40% of maximum contraction) isometric knee flexion contraction for 7–10 seconds against the examiner's shoulder. The leg was then passively stretched for 30 seconds to the felt limit or tolerance to strain, after which there was a 2-3 second period of rest.After that, the leg was left back on

the plinth for a quick 8–10-second rest. To mitigate the effect of the technique on blood pressure [21]and,minimize compensatory muscle activation during isometric contraction, the patient was advised to maintain regular breathing patterns and refrain from elevating their hips. There were two further iterations of this process.

The Reciprocal Inhibition Met Technique

It was used to apply MET. The afflicted muscle is positioned in the middle. The therapist either permits a movement towards the restriction/barrier (isotonic) or entirely rejects the patient's drive towards it (isometric). After the patient has relaxed and exhaled, the therapist appliesa passive stretch to the newly formed barrier [17]. The subject engaged in a moderate, around 35–40% maximal contraction, knee flexion isometric contraction for seven to ten seconds against the examiner's shoulder. There will be a 2-to 3-second pause after this [22]. After that, the leg will be passively extended for 30 seconds to the palpable barrier or tolerance.

Tens (Conventional therapy): I used TENS with two channels and 3 x 5 cm electrodes over the surgical site after therapeutic exercise and muscle energy technique. This delivered continuous high-frequency TENS (conventional mode) to the patients. The settings were 120 Hz frequency, 100 μs pulse width, and sensory-level intensity to produce strong paresthesia without pain [23].

Outcome measure:

NPRS (Numerical Pain Rating Scale): An instrument used to quantify the level of pain in adults is the Numeric Pain Rating Scale (NPRS), which is one-dimensional. "0" denotes one extreme of pain (for example, "no pain"), while "10" denotes the opposite extreme of pain (for example, "pain as bad as you can imagine" or "worst pain imaginable"). The 11-point numerical scale runs from 0 to 10 [23].

Goniometer: Following surgery and at every follow-up, range of motion was measured on both sides. There was a standard portable goniometer used. The values were rounded up to the next whole number, five. The patient was in the supine position when the extension measures were taken, and the patient was in the flexion position when the heel was slid as near to the buttocks as possible without the assistance of the arms.

KOOS Scale: KOOS-QoL and ACL-QoL were used to measure knee-related quality of life. One of the five KOOS subscales, the KOOS-QoL assesses the quality of life-related to the knee[24]. Among all the subscales, the KOOS-QoL exhibits the best content validity and the highest responsiveness among young people with knee

injuries[25]. The ACL-QoL was created to evaluate extra areas of knee-related QoL unique to a young, active population with ACL injuries, such as work-related, social, and emotional domains[26]. A total score of 100 is calculated using the KOOS-QoL and ACL-QoL (0 being extremely difficult difficulties and 100 being no problems). Content validity (Cronbach's alpha > 0.76), test-retest reliability (ICC > 0.86), and responsiveness (effect sizes > 0.5) have all been demonstrated by the KOOSQoL and ACL-QoL[25,26].The MDC for KOOS-QoL is 8–10 points[25], and ACL-QoL scores of 12 [26].
The sport, pain, and symptom KOOS subscales were evaluated and added to the KOOS-QoL to get the total KOOS score. After an ACL damage, the KOOS individual subscales are responsive, valid, and trustworthy[27].

Statistics Analysis: The distribution of the results was evaluated using descriptive statistics. The results were presented as mean values (x) and standard deviations (SDs) using the student-t test to assess statistical significance.Statisticalsignificance was accepted at the level $p<0.005$.

Result: A total of 12 patients underwent arthroscopic ACL reconstruction. All subjects who started the intervention completed the study without losses or exclusions. The demographic characteristicsare age, Gender, and Height.Group A has four males and two females with a mean of 0.67 for both with differentanSD (0.516 for men and 1.03 for women) and Group B has three males and three females with a mean of 28.5 with different standard deviations (6.48 for males and 1.2 for female). The mean age for group A was 27.67 with a standard deviation of 4.50 and the mean age of group B was 28.5 with a different standard deviation of 6.48. The mean height of group A was 162.34 with a different standard deviation of 8.09 and the mean height of group B was 163.47 with a different standard deviation of 8.476 (Table 2).

Table 2. Participants' Socio-Demographic Characteristics.

Variable		**Type**	**N**	**Mean**	**Std. Deviation**
Age (Yrs.)		Group A	6	27.66667	4.501851
		Group B	6	28.5	6.473021
Gender	Group A	Male	4	0.666667	0.516398
		Female	2	0.666667	1.032796
	Group B	Male	3	28.5	6.473021
		Female	3	0.5	1.2
Height (cm)		Group A	6	162.33	8.095
		Group B	6	163.47	8.476

Table3. The Statistical analysis Mean, Standard Deviation, and P value for NPRS Scale on 2nd to 5 weeks and 1 month follow-up

GROUPS	STATICAL ANALYSIS	2ND Day	3rd week	5th week	1 month follow up
GROUP A	N	6	6	6	6
	Mean	8.166667	4.333333	1.666667	1.333333
	Std, Deviation	0.752773	0.516398	0.516398	0.516398
	P value	0.5	0.00516	0.23251	0.00205
GROUP B	N	6	6	6	6
	Mean	8.166667	5.666667	2	1.833333
	Std, Deviation	0.752773	0.516398	0.632456	0.408248
	P value	1	0.01032	0.46502	0.0041

Both A and Bgroups indicate similar statical analysis for 2nd day of treatment in terms of meanand SDbutthe P valueof Group A is half of Group B. The P value of Group B is twiceof Group A throughout treatment. It is observed that the mean value of group A (1.34) decreased as compared to group B (1.83) rapidly. It is also observed the Standard deviation of Group A (0.51)was constant after 3rd week but high variations are present in Group B(0.64) (Table 3).

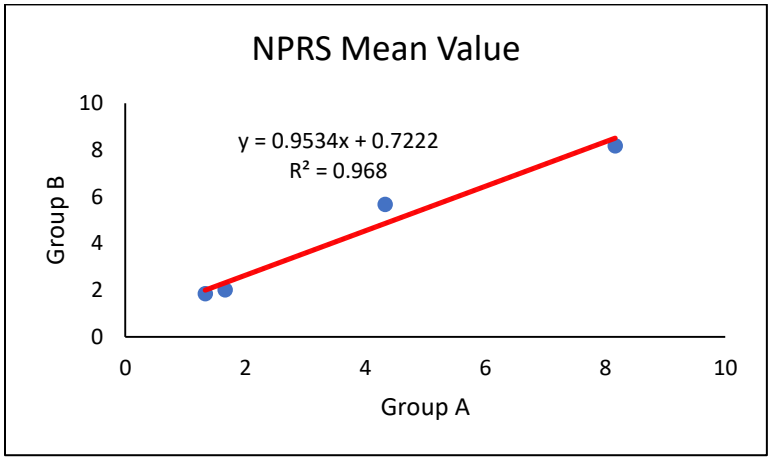

Figure 2. Graphical represents NPRS Mean Value.

The regression analysis of the NPRS scale shows a strong relation (r^2=0.968) between Group A and Group B mean values under regression analysis (Fig. 2).

Table 4. The statistical Analysis Mean, Standard Deviation, and P value for the Goniometer (Knee flexion ROM) on 2nd to 5 weeks and 1-monthfollow-up

GROUPS	STATISTICAL ANALYSIS	2ND Day	3rd week	5th week	1 month follow up
GROUP A	N	6	6	6	6
	Mean	34.16	76.67	105.83	128.33
	Std, Deviation	1.59	2.47	1.54	2.108
	P value	0.55	0.014	0.0005	5.24E-05
GROUP B	N	6	6	6	6
	Mean	29.17	67.5	89	105
	Std, Deviation	1.54	2.15	1.87	2.59
	P value	0.12	0.02	0.002	0.0001

Table 4 shows the mean, SD and P value of the goniometer. On the 2nd day, the mean value of group A was 34.16 with aSDof 1.59and the mean value of group B was 29.17 with a standard deviation of 1.54. The mean value continues to increase as compared to the 3rd week to 1-month follow-up treatment protocol of both groups. The P value of Group A (P<0.0005) and Group B p-value (P<0.0001) indicate a highly significant difference between groups.

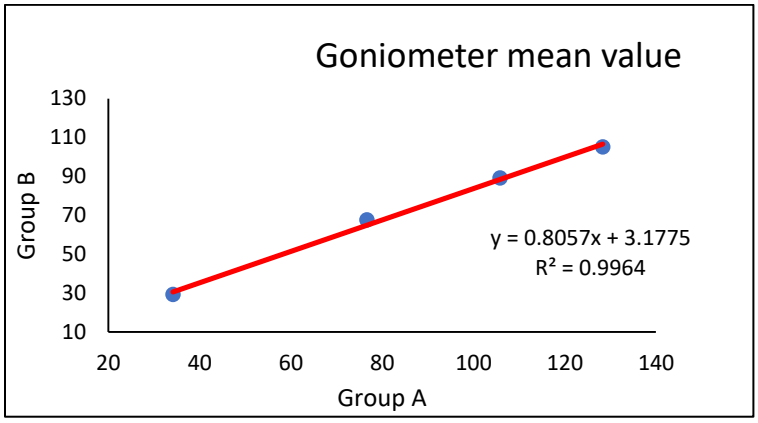

Figure 3. Graphical represent Goniometer (knee Flexion ROM) Mean value

The regression analysis of the Goniometer shows a strong relation (r^2=0.9964) between Group A and Group B mean values under regression analysis (Fig. 3).

Table 5. Mean, Standard Deviation, and P value for KOOS (Pain)on 2nd to 5 weeks and 1 month follow-up

GROUPS	STATISTICAL ANALYSIS	2ND Day	3rd week	5th week	1 month follow up
GROUP A	N	6	6	6	6
	Mean	3.907407	3.37037	2.759259	2.37037
	Std, Deviation	0.196855	0.167283	0.257401	0.167283
	P value	0.240355	0.000889	0.001933	0.000001
GROUP B	N	6	6	6	6
	Mean	4	4.138889	3.436111	3.222531
	Std, Deviation	0.20286	0.221527	0.294471	0.072297
	P value	0.48071	0.001779	0.003866	0.000002

A statistical Analysis was performed for Groups A (therapeutic exercise with TENS) and B(MET with TENS).Based on the result, the p-value ($p<0.000001$) of Group A is less than that of the p-value ($p<0.000002$)of Group B for all the observation time. The SD and mean for 2nd day are almost similar. After the treatment of 3rd week, the mean value and SDof Group A are below than mean value and standard deviation of Group B(Table 4).

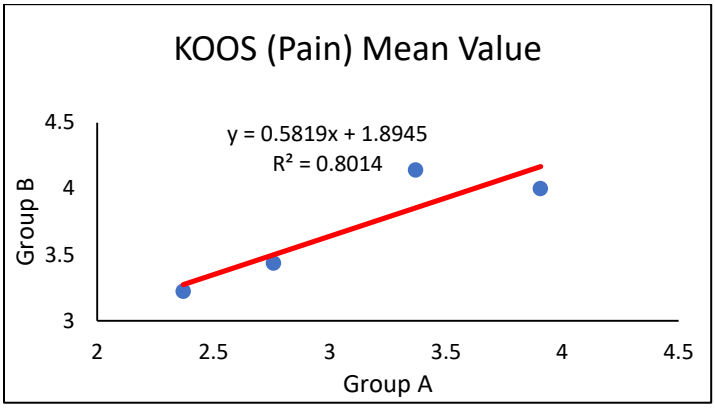

Figure 4. Graphical represents KOOS (Pain) Mean Value.

The regression analysis of the KOOS (pain) scale shows a strong relation ($r^2=0.8014$) between Group A and Group B mean values under regression analysis (Fig. 4).

Table 6. Mean,Standard Deviation, and P value for KOOS (Symptom) on 2nd to 5 weeks and 1 month follow-up

GROUPS	STATISTICAL ANALYSIS	2ND Day	3rd week	5th week	1 month follow up
GROUP A	**N**	**6**	**6**	**6**	**6**
	Mean	3.857143	3.190476	2.285714	2.214286
	Std, Deviation	0.255551	0.265986	0.127775	0.267261
	P value	0.244637	0.00801	0.000261	0.004141
GROUP B	**N**	**6**	**6**	**6**	**6**
	Mean	3.959184	3.785714	3.02381	2.928571
	Std, Deviation	0.257067	0.196915	0.318372	0.346999
	P value	0.489273	0.016019	0.000523	0.008282

Table 6 shows a statistically significant improvement in KOOS (symptom). Based on the result the P value ofgroup A (P<0.0041) is less than thatof group B (P>0.0082) for all the observations. The standard deviation and mean on the second day are almost similar. After the treatment of the 5thweek, the mean value of Group A (2.29), SD (of 0.12) is below the Group B mean (3.02), and the SD (0.32) (table 6).

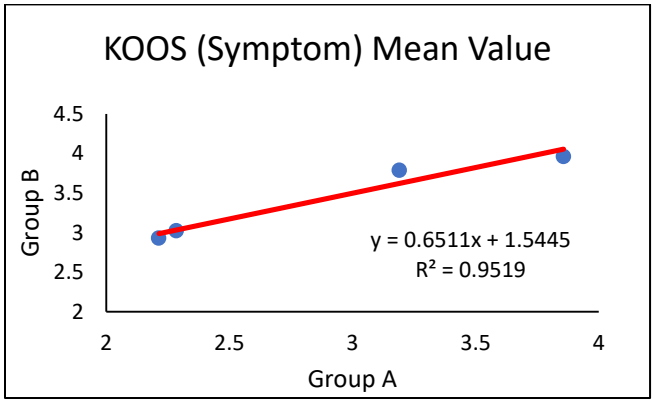

Figure 5. Graphical represents KOOS (Symptom) mean value

The regression analysis of the KOOS (Symptom) scale shows a strong relation (r^2=0.968) between Group A and Group B mean values under regression analysis (Fig. 2).

Table 7. The statistical Analysis Mean, Standard Deviation, and P value for KOOS (ADL) on 2nd day, 3rd week, 5th week, and one-month follow-up.

GROUPS	STATISTICAL ANALYSIS	2ND Day	3rd week	5th week	1 month follow up
GROUP A	N	6	6	6	6
	Mean	4.313725	3.352941	2.392157	2.196078
	Std, Deviation	0.080368	0.134138	0.088561	0.109523
	P value	0.0506947	8.044E-05	0.0001787	0.0015277
GROUP B	N	6	6	6	6
	Mean	4.2387255	3.921569	3.27451	2.940564
	Std, Deviation	0.0625418	0.030376	0.259536	0.398963
	P value	0.1013894	0.0001609	0.0003574	0.0030554

The above table shows a statistically significant improvement in KOOS (ADL). The P value group A (P<0.0016) and group B (P<0.0031)signifies a highly significant difference. On the 2nd day of the treatment Group A mean of 4.32 with an SD of 0.80 was slightly less than Group B meanof 4.24 with an SD of 0.07. The means and SD decreased after the 5th-week group A and B treatment (Table 7).

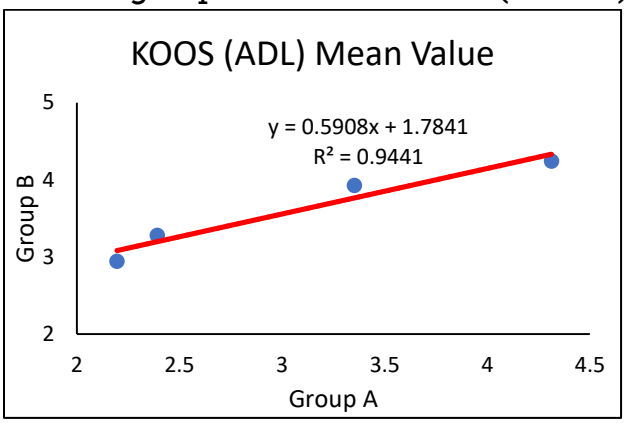

Figure 6. Graphical represents KOOS (ADL) Mean value

The regression analysis of the KOOS (ADL)Scale shows a strong relation (r^2=0.9441) between Group A and Group B mean values under regression analysis (Fig. 6).

Table 8. The statistical Analysis Mean, Standard Deviation, and P value for KOOS (sports and recreation and function) on 2nd to 5 weeks and 1-month follow-up.

GROUPS	STATISTICAL ANALYSIS	2ND Day	3rd week	5th week	1 month follow up
GROUP A	N	6	6	6	6
	Mean	4.9	2.966667	1.766667	1.533333
	Std, Deviation	0.109545	0.08165	0.294392	0.163299
	P value	0.27064	0.0000004	0.000498	0.000247
GROUP B	N	6	6	6	6
	Mean	4.833333	3.933333	2.733333	2.433333
	Std, Deviation	0.233809	0.10328	0.206559	0.320416
	P value	0.54128	0.0000009	0.000997	0.000494

The result in the above table shows a statistically significant improvement in KOOS (Sports and recreation and function) after the 2nd day, 3rd week, 5th week, and one-month follow-up as evidenced by a 5th week and 1-month follow-up compared to the 2nd day mean. The P value group A (P<0.0025) and group B (P<0.0005) signifies a highly significant difference (Table 8).

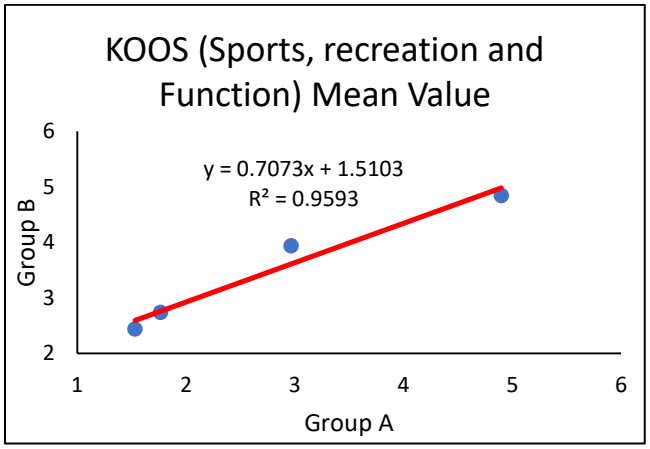

Figure 7. Graphical represents KOOS (Sports, recreation, and Function) Mean value

The regression analysis of the KOOS (Sports, recreation, and function) scale shows a strong relation (r^2=0.9593) b

etween Group A and Group B mean values under regression analysis (Fig. 7).

Table9. Statistical AnalysisMean, Standard Deviation, and P value for Quality of life (KOOS) on 2nd to 5 weeks and 1-month follow-up

GROUPS	STATISTICAL ANALYSIS	2ND Day	3rd week	5th week	1 month follow up
GROUP A	N	6	6	6	6
	Mean	4.916667	3.125	1.833333	1.541667
	Std, Deviation	0.129099	0.262202	0.204124	0.33229
	P value	0.170447	0.025973	0.025973	0.001739
GROUP B	N	6	6	6	6
	Mean	4.75	3.708333	2.583333	2.291667
	Std, Deviation	0.387298	0.36799	0.258199	0.36799
	P value	0.340893	0.051946	0.051946	0.003478

The above table shows a statistically significant improvement in KOOS (Quality of life) after the 2nd day, 3rd week, 5th week, and one-month follow-up, as evidenced by a 5th week and 1-month follow-up compared to the 2nd day mean. The P value group A (P<0.0018) and group B (P<0.0035)signifies a highly significant difference.Group A mean and standard deviation are lesser than Group B and standard deviation on the 5th week after the treatment.

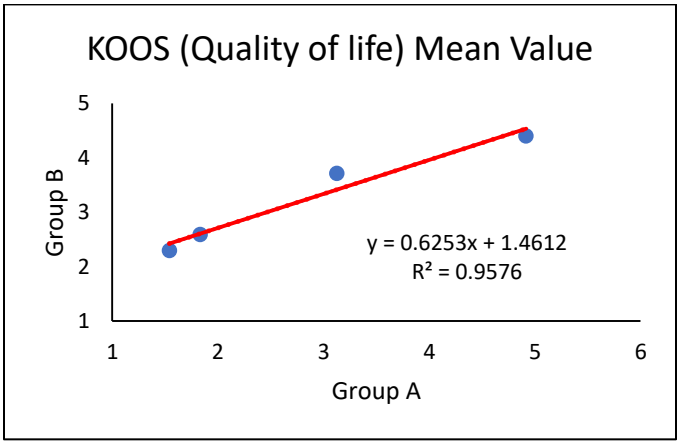

Figure 8. Graphical representation KOOS (Quality of life) Mean value

The regression analysis of The KOOS (Quality of life) scale shows a strong relation (r^2=0.9576) between Group A and Group B mean values under regression analysis (Fig. 8).

Conclusion

This study showed that therapeutic exercise with high-frequency TENS hasa better effect than the muscle energy technique with High-frequency TENS, on improving pain, ROM, and quality of lifein patients after ACL reconstruction of the knee. The mean value of group A and group B shows strong bonding in all the outcome measures (NPRS, Goniometer, and KOOS). The P value of group B is always two times of group A.

Ethical Considerations:

Compliance with Ethical Guidelines: This study was approved by the ethical committee of NIMS University (Code: NIMS/PT/OT/April/2024/46, dated 3.4.2024

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