International Journal of Research and Review
DOI: https://doi.org/10.52403/ijrr.20210630
Vol.8; Issue: 6; June 2021
Website: www.ijrrjournal.com
Original Research Article *E-ISSN: 2349-9788; P-ISSN: 2454-2237*

Comparison of Effectiveness of Cryotherapy and Neuromuscular Electrical Stimulation (NMES) on Pain, Range of Motion and Gait Speed in Early Post-Operative Phase in Subjects with Unilateral Total Knee Arthroplasty

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ABSTRACT

Introduction: In acute phase after Total Knee Arthroplasty (TKA), physiotherapy, aims at reducing pain, local edema and muscle weakness. Among treatment techniques, cryotherapy increases pain tolerance, helping in uninhibited motor recruitment of quadriceps. Intermittent muscle fiber contraction with Neuromuscular Electrical Stimulation (NMES) improves blood flow, reduces pain and decreases quadriceps arthrogenic muscle inhibition. Exercise therapy causes muscle strengthening. Effects of perioperative cold therapy have conflicting evidences. Early NMES use, post TKA for pain and swelling reduction has shown paucity of literature. Hence, this study aims to compare the effectiveness of these techniques in improving function.

Method: Interventional study was conducted with 30 subjects randomly allocated into two groups (Group A- cryotherapy and Group B- NMES). Both received standardized exercise therapy. On 2nd postoperative day- pain (using Visual Analog Scale), Range Of Motion (using universal goniometer) and gait speed (using 4 metre walk test) was measured. Treatment was given for 5 days according to allocated group. Post-treatment outcome measures were taken.

Results: Out of 30 participants, both groups showed statistically significant ($p<0.05$) improvement in all outcomes. Comparing effectiveness between the groups, NMES showed statistically significant improvement for knee flexion ROM. Other outcome measures showed no statistically significant difference.

Conclusion: Rehabilitation in acute phase is essential for improving patient's strength in long term. Along with exercise therapy, both cryotherapy and NMES showed improved function. On comparison, NMES showed better results for improvement in knee flexion ROM.

Key Words: Total Knee Arthroplasty, cryotherapy, neuromuscular electrical stimulation, exercise therapy, visual analog scale, range of motion, gait speed

INTRODUCTION

Osteoarthritis (OA) of knee is the most common form of arthritis with an overall prevalence of approximately 28.7% in India. [1]

In the process of osteoarthritis, degradative enzymes are overexpressed, resulting in an overall loss of collagen and proteoglycans. These changes result in cracking and fissuring of the cartilage and erosion of the articular surface. As the disease advances, periarticular muscle weakness and atrophy, remodelling of subarticular bone, osteophyte formation, ligamentous laxity and synovial effusion

occur [2] Knee osteoarthritis can be divided into two types, primary (articular degeneration without any apparent underlying reason) and secondary (caused by another disease or condition). Knee OA affects the 3 compartments of the knee joint (medial, lateral and patellofemoral joint) interfering with daily life activities. [3]

Total Knee Arthroplasty (TKA), also known as total knee replacement (TKR), is one of the most commonly performed orthopedic procedures. About 70,000 joint replacement surgeries were performed in 2011 in India with expected growth rate of 26.7% till 2017. [4] TKR due to OA is the commonest with 93.98%. Other causes include rheumatoid arthritis (5.47%), ankylosing spondylitis, traumatic arthritis and post infective arthritis (0.54%). [5]

The primary indication for TKA is to relieve pain caused by severe arthritis, with or without significant deformity. Absolute contraindications to TKA include recent or current knee sepsis, a remote source of ongoing infection, extensor mechanism discontinuity or severe dysfunction, recurvatum deformity secondary to muscular weakness.

TKA can be classified as [6]:

1. **On method of fixation:** Cemented, uncemented, hybrid.
2. **On degree of constraint built in prosthesis:** Unconstrained, semiconstrained or fully constrained.
3. **On number of components replaced:** Unicompartmental, bicompartmental or tricompartmental
4. **On status of Posterior Cruciate Ligament (PCL):** can be posterior cruciate retaining or cruciate excising.

TKA results in large improvements in pain, mobility, function and health-related quality of life. However, in early post-operative phase, it causes a severe localised inflammatory response in the soft tissues of the knee, with local hemorrhage and haematoma formation, which reaches its peak in the first few hours after surgery [7].

Pain, swelling and surgical damage to knee joint reduces excitatory input to muscles surrounding the affected joint. The presence of edema may also affect neural regulation of muscle tone, via Ruffini ending influences on Golgi Tendon Organ. This results in failure of recruiting all available motor units of quadriceps muscle despite maximal voluntary effort or a reduction in the maximal motor unit discharge rate from recruited motor units. [8] This reduction in all available force production is called arthrogenic muscle inhibition (AMI). Motor cortical mechanisms impact quadriceps activation deficits following TKA. [9] These neural mechanisms causing quadriceps Central Activation Deficit (CAD), which is already prevalent in individuals with knee OA, are magnified after TKA, resulting in more severe muscle weakness than prior to surgery. Also, quadriceps muscle atrophy increases post surgery which further leads to quadriceps weakness. [10],[11] Even though TKA provides significant pain relief and improves self-reported function, this procedure may not improve the quadriceps muscle strength to the normal level for age-matched healthy population. [12]

Physiotherapy post TKA aims at decreasing pain and swelling, increasing Range Of Motion (ROM), muscle strength and thus, improving mobility. Management techniques include cryotherapy, NMES, exercise therapy, aquatic therapy etc. [13]

Cryotherapy or cold therapy has clinical applications in pain control since the 1960. [14] It reduces the intra-articular temperature. [15] It produces a number of physiological effects like reduction in blood flow, edema, haemorrhage, cellular metabolic rate, hypoxia, enzymatic activity and tissue damage. It significantly increases the pain threshold and pain tolerance by reducing nerve conduction velocity, thereby, reducing the transmission of noxious signals and inflammatory response. These effects help in uninhibited motor recruitment, thereby, restoring the neuromuscular control and in overall rehabilitation process [10]. Varieties of devices have been designed to deliver controlled cryotherapy like ice

packs, cryocuff, chemical cold packs. **Ice packs are used for this study.**

Neuromuscular Electrical Stimulation (NMES) involves using a device that transmits an electrical impulse to activate muscle groups (quadriceps) through electrodes. NMES has effects on pain relief by increasing blood flow, by pain gate mechanism, endorphin release and counter-irritation effects due to muscle contractions. [16] It reduces quadriceps arthrogenic muscle inhibition, early after surgery, by motor neuron activation. [17] It targets the larger force-producing type II (fast-twitch) fibers resulting in reversal of activation deficits and promoting greater quadriceps strength gains. [11] Stimulation of peripheral afferent nerves via NMES can induce prolonged changes in the excitability of the human motor cortex. NMES may affect central activation deficits, thereby, allowing restoration of normal quadriceps muscle function more effectively than voluntary exercise alone. [17]

Increases in the ROM and pain relief are two main measures of a successful TKA and is directly related to the patient's being physically active. Gait speed has the potential to predict future functional decline and fall risk. Hence, pain, ROM and gait speed are the outcome measures used in the study.

1) Pain: The pain **Visual Analog Scale (VAS)** (r = 0.94) in postoperative patients. [18] It is a unidimensional measure of pain intensity widely in adult populations.
2) **Range Of Motion (ROM)** is measured by universal goniometer, which is a metal or plastic handheld device with two arms. Numbers representing angular distance are on the device.
3) **Gait speed** is a quick, inexpensive, reliable measure of functional capacity. An average elderly gait speed to travel independently in community, ranges from 0.60 to 1.45 m/s with 0.46m/s in acute care settings compared to 0.74 in outpatient settings. [19]

Thus, this study is conducted with a view to compare the effectiveness of two non-invasive techniques i.e. NMES and cryotherapy in reducing pain, improving ROM and gait speed in immediate post-operative period. The use of these techniques helps in improving the functioning to a higher level than with exercise alone. Also, with the rise in TKA surgeries being performed in India, this study will help to formulate treatment goals and make clinical decisions in our rehabilitation process.

MATERIALS AND METHODOLOGY

Comparative, interventional, prospective, blinded study was conducted in Orthopaedic Indoor Patient Department of a tertiary care hospital. Institutional ethics permission was obtained.

Total sample size was 30 with 15 subjects in each group A (Cryotherapy) and group B (NMES). Convenient sampling with random allocation was done by block randomization process. Allocation was done by computer generated random number table. Single blinding was done as the study investigator was not aware of treatment proposed.

Those patients willing to participate between age groups 60-85 were included in study. All subjects had undergone unilateral Total Knee Arthroplasty for osteoarthritis. All patients were selected from one surgical unit to avoid surgical bias. Surgery was done with medial parapatellar approach, with cemented femoral and tibial components and whose posterior cruciate ligament was retained. Medications of these patients were standardized and not modified during study. Study duration was for 6 months (November 2018 to April 2019).

Patients with any past history of injury or surgical treatment of lower limb, neurological or vascular deficit (peripheral vascular disease), inflammatory disorder, infective condition, bleeding diathesis, revision TKR, uncontrolled diabetes and hypertensive disorders, any kind of psychiatric or cognitive disorders, patients

with post - surgical complications like Deep vein thrombosis, patients with contralateral knee pain (VAS on activity>4/10) on second post-operative day were not included in study.

Fig 1. Instruments used

Fig 2. Walkway

Methodology:

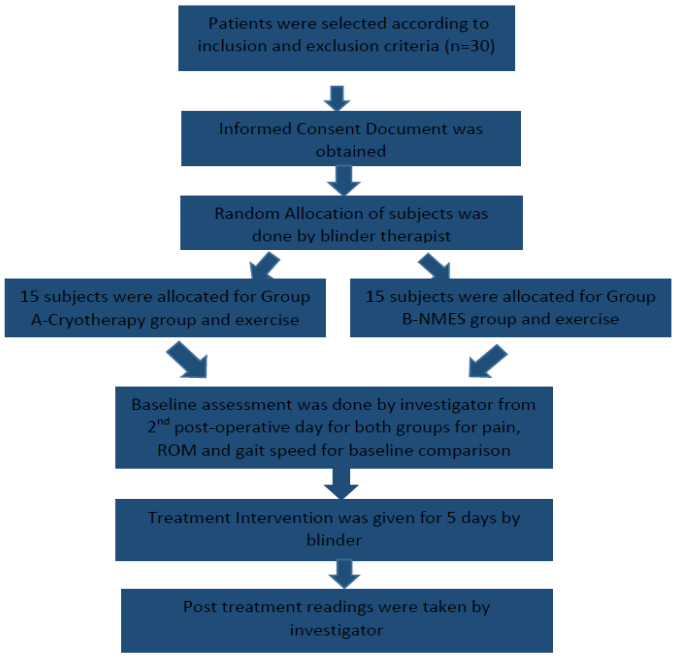


Figure 3.Methodology

Cryotherapy application method [20]:

Fig 4.Cryotherapy application technique

a) Patient was in supine position with the operated knee in maximum possible extension.
b) An ice bag i.e.zip lock plastic bag filled with ice cubes, of 15 X15 cm, was placed on the operated knee joint.
c) It was covered with towel to decrease heat gain to the ice pack from outside air and was secured with Velcro strap.
d) The temperature of ice bag was maintained between 4-5ºC.
e) It was applied for about 20 minutes.
f) Intermittently, thermometer was placed below patella and above the tibial tuberosity to ensure uniform cooling [21].
g) Care was taken to avoid post ice application skin temperature drop below 18ºC, to avoid patient discomfort

NMES application method [10]:

Fig 5.NMES application technique

a) Patient was in supine position with the operated knee in maximum possible extension.
b) Flexible electrodes were placed on the distal medial and lateral portions of the patient's anterior thigh.
c) The patient was counseled to relax during the procedure and feel the muscle contractions.
d) NMES by Faradic current was applied from the portable electrical stimulator to the patient's resting quadriceps muscle for 30 contractions at the intensity which the patient can tolerate.
e) Intensity was increased as tolerated during each session.
f) All contractions were isometric.
g) Surge interval was more than surge duration to prevent muscle fatigue. [20]

Physiotherapy exercises included:

a) The exercises, which increased passive and active knee ROM along with lower extremity strengthening (mainly of the quadriceps and gluteal muscles), were given for about 10 contractions for each exercise twice a day.
b) Exercises which were included are static quadriceps, static glutei, heel slides, straight leg raise with brace, supine hip abduction, dynamic quadriceps and core muscle activation. [22]
c) Gait training activities to restore a normal gait pattern with the walker gradually progressing to walking stick.

Outcome measures assessment techniques:

1. Pain Assessment:

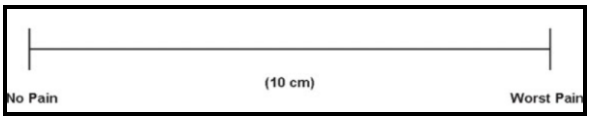


Fig 6. Visual Analog Scale

- On second post-operative day, patients were asked to rate their knee pain on a VAS scale (0-10cm scale) drawn, where 0 indicates no pain and 10 represents the "worst pain imaginable. [23]

- This was repeated after 5 days of treatment on a new VAS scale.

2. ROM Assessment: (Intra ICC= 0.97–0.99 and Intra r= 0.97–0.99 for passive knee flexion and Intra ICC=0.91–0.97 and Intra r= 0.91–0.96 for passive knee extension). [24]

- On second post-operative day, **passive knee ROM was taken**.

ROM assessment for knee:

a) Testing Position:

The subject was in supine position, with the knee in extension. Hip was positioned in neutral position.

b) Stabilization: Femur was stabilized to prevent rotation, abduction and adduction of the hip.

c) Testing Motion:

i. The subject's ankle was held in one hand and the posterior thigh with the other hand. The knee was moved passively into flexion.

ii. The end of the range of knee flexion occured when resistance was felt and attempted to overcome the resistance causes additional hip flexion.

iii. Knee extension range was recorded from original possible flexion till available extension range. Thus, extension was relative to flexion.

Fig 7. Knee flexion ROM

Fig 8. Knee extension ROM

d) Goniometer Alignment:

i. Fulcrum of the goniometer was placed over the lateral epicondyle of the femur.

ii. Proximal arm was aligned with the lateral midline of the femur, using the greater trochanter for reference.

iii. Distal arm was aligned with the lateral midline of the fibula, using the lateral malleolus and fibular head for reference.

iv. The same was done after 5 days of cryotherapy or NMES treatment.

3. Gait speed assessment by 4 metre walk test (ICC=0.94) [25]:

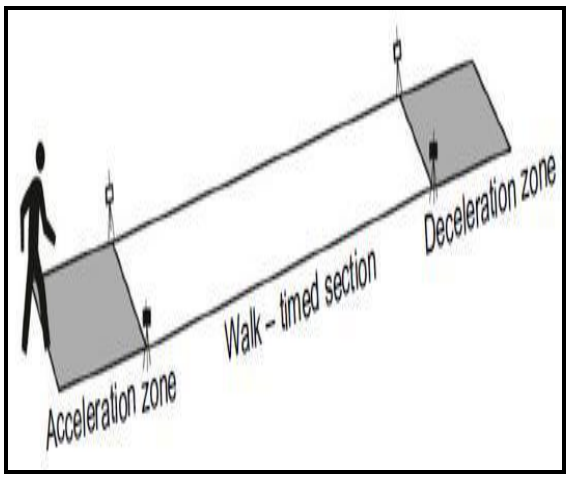


Fig 9. Gait Speed walkway

Fig 10. Gait Speed measurement technique

- The 4-meter walk test measures walking speed in meter/second over a short period of time.
- It was measured on the second post-operative day.
- Test Procedure:

i. A 4-meter distance was measured. Start and end points on the floor were marked.
ii. A short "acceleration" and "deceleration" zone of 2 metres was included outside the data collection area to help reduce gait variability introduced during these phases. All patients were allowed to use assistive device (i.e.walker).
iii. Assessment Instructions: The patients were asked to begin in the acceleration zone.
iv. Verbal Instructions to patient were given that after saying "begin", they should walk as fast as possible until told to stop. Timing was started on the stopwatch as soon as the patient's leg passed over the starting line and stopped when the leg has crossed the second mark i.e. the 4- meter mark or entered the deceleration zone.
v. Two walking trials were completed with a rest pause in between.
vi. For each of the two trials, time needed to walk four meters were recorded.
vii. Patient's gait speed (meter/second), as the average of the two trials, were taken.[26]

Statistical Analysis:

Data for statistical analysis was entered using Microsoft Excel version 2010. Statistical Analysis was performed using Excel 2010 and Graphpad prism version 8.1.2. In this study, baseline matching between two groups was done for pain, ROM (flexion and extension) and gait speed by comparing pre intervention values between the 2 groups – one receiving cryotherapy and other receiving NMES. Exercise rehabilitation was given to both groups. Also, within the group, comparison was done for both treatment groups. Results of post 5 days intervention on outcome measures between both the groups were compared.

Shapiro Wilk test was used for finding normality of data. Level of significance was set at level less than 0.05($p<0.05$). The data was analysed. VAS being an ordinal scale was compared using median and interquartile range.

Comparison between two groups for pain was done using Mann-Whitney U test. Baseline data passed normality test for flexion and extension ROM and for gait speed. Hence, unpaired t-test was used for comparing data.

For group receiving cryotherapy treatment, pain values on VAS scale were taken pre and post 5 days of cryotherapy sessions. It was analysed using Wilcoxon signed rank test was used. Flexion and extension ROM passed normality test. Hence, was analysed using paired t-test. Gait speed values post cryotherapy intervention did not pass the normality test, hence comparison of effectiveness of treatment was done using Wilcoxon-signed rank test.

For within NMES treatment intervention group, pain was analysed using Wilcoxon signed rank test. Flexion and extension ROM and gait speed values pre and post 5 days intervention passed normality test and hence were compared with paired t-test.

Comparison between the groups after 5 days of treatment for pain was analysed using Mann-Whitney U test. Flexion ROM which passed normality test was compared using unpaired t-test. Extension ROM and gait speed between the groups did not pass normality test, hence was analysed using Mann-Whitney U test.

RESULTS

This study was completed with 30 participants (3 males and 27 females). Their age ranged from 60 to 68 years with mean age of 62.97 years in both groups. 14 subjects had received TKA on left side and 16 on right side.

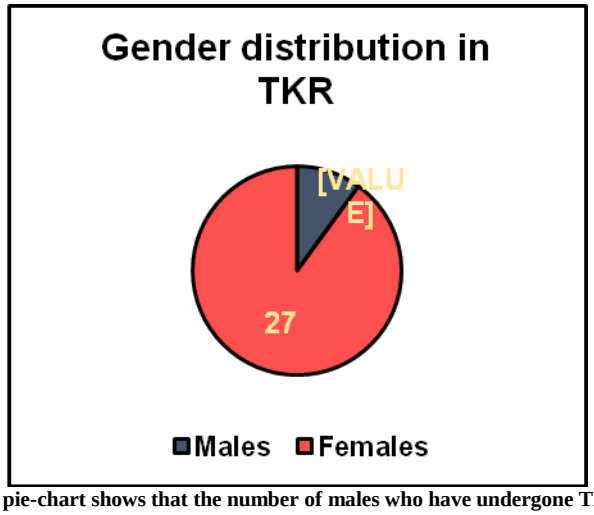


Fig.11.This pie-chart shows that the number of males who have undergone TKR is 10%.

It shows that TKR surgeries are done at higher rate in females than males.

Table 1: General and clinical characteristics of study participants

Serial number	Variables	Group A (cryotherapy)	Group B (NMES)	p value
		(n=15)	(n=15)	
1	Age	63	62.93	
2	Gender (M/F)	2/13	1/14	
3	Operated side(R/L)	6/9	10/5	
4	Pain(VAS)	8.3±(1.1)	8.3±(1.3)	0.8942
5	Flexion ROM (degree)	49.067±(13.76)	44.867± (10.494)	0.3554
6	Extension ROM (degree)	22±(8.759)	20.2±(8.402)	0.5703
7	Gait Speed (m/s)	0.070±(0.027)	0.060±(0.018)	0.2595

General characteristics of two groups of patients with 15 participants in each group–one group receiving cryotherapy and other receiving NMES is given in table 1.

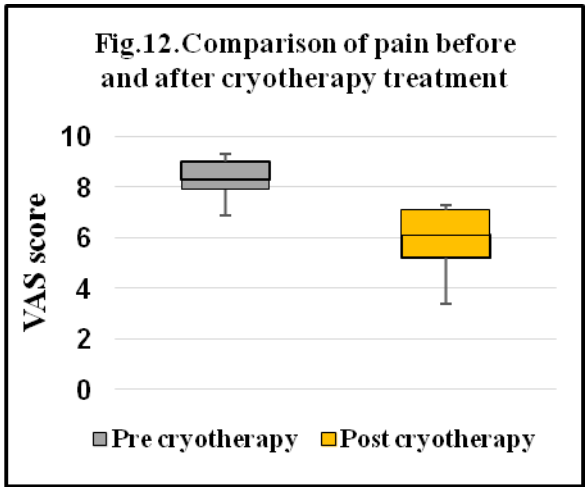
Values of VAS are represented as Median ± (Interquartile Range).Other values are represented as mean±(Standard Deviation)

Table 1 shows that there is no significant difference in baseline readings between two groups of patients in outcome measures of pain, ROM of flexion and extension and gait speed. Hence, these two groups can be compared.

Within - group comparison of group A (cryotherapy):

Table 2: Comparison of pain within cryotherapy group (Group A)

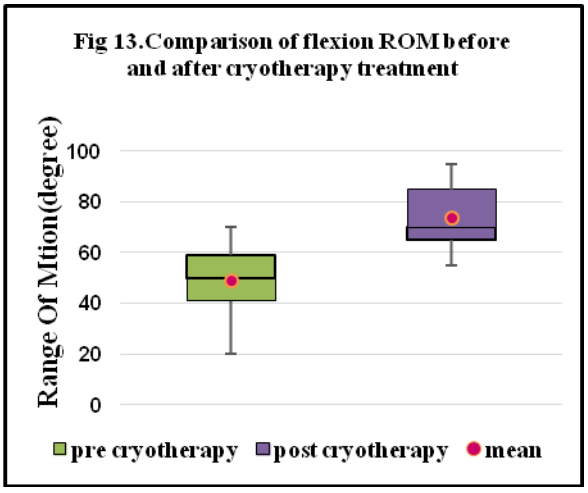
Pain(VAS)	Pre intervention	Post 5 days intervention	p value
Median±(IQR)	8.3±(1.1)	6.1±(1.9)	p<0.0001



The above graph and table shows statistically significant reduction in pain post 5 days of cryotherapy treatment.

Table 3 :Comparison of flexion ROM within cryotherapy group (Group A)

Flexion ROM (degree)	Pre intervention	Post 5 days intervention	p value
Median±(IQR)	50±18	70±(20)	p<0.0001
Mean±(S.D.)	49.067±(13.766)	73.6±(13.611)	



The above graph and table shows statistically significant increase in flexion ROM post 5 days of cryotherapy treatment.

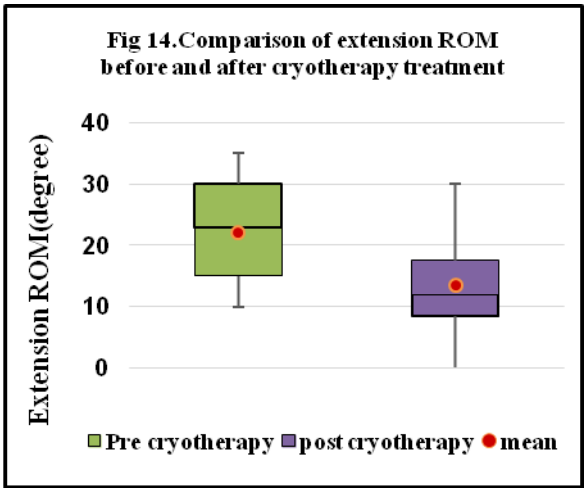
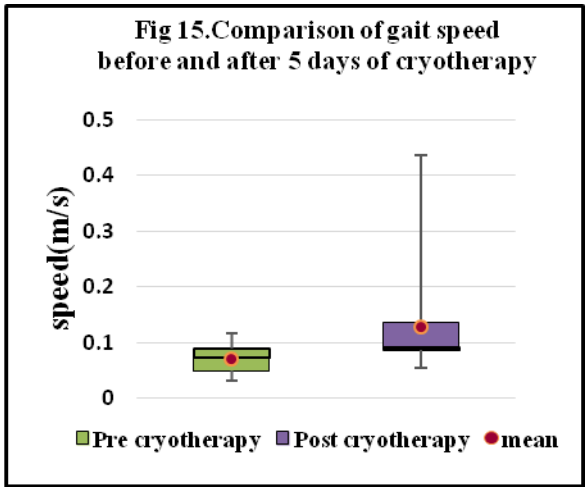


Table 4: Comparison of extension ROM within cryotherapy group (Group A)			
Extension ROM(degree)	**Pre intervention**	**Post 5 days intervention**	**p value**
Median±(IQR)	23±(15)	12±(9)	p<0.0001
Mean±(S.D.)	22±(8.759)	13.467±(8.585)	

The above graph and table shows statistically significant improvement in extension ROM post 5 days of cryotherapy treatment.

Table 5:Comparison of gait speed within cryotherapy group(Group A)			
Gait Speed(m/s)	**Pre intervention**	**Post 5 days intervention**	**p value**
Median±(IQR)	0.072±(0.0385)	0.092±(0.0495)	p<0.0001
Mean±(S.D.)	0.070±(0.027)	0.127±(0.092)	

Abbreviation-metre/second(m/s)



The above graph and table show statistically significant increase in gait speed post 5 days of cryotherapy treatment.

Within - group Comparison of Group B (NMES group):

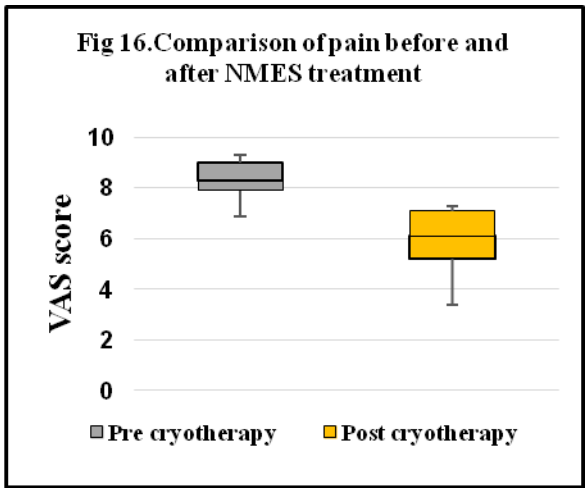
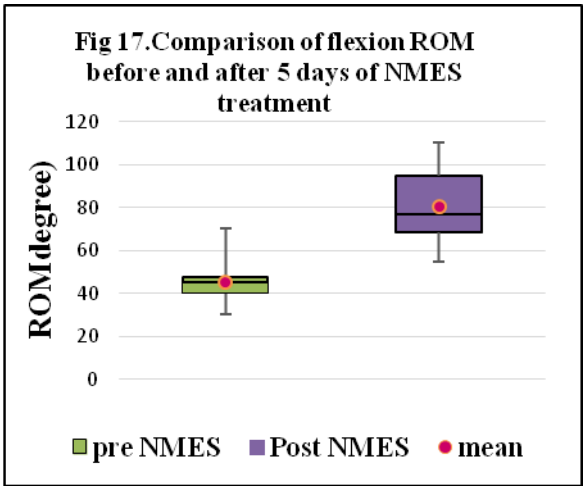


Table 6 :Comparison of pain within NMES group (Group B)			
Pain (VAS)	**Pre intervention**	**Post 5 days intervention**	**p value**
Median±(IQR)	8.3±(1.3)	5.2±(1.15)	p<0.0001

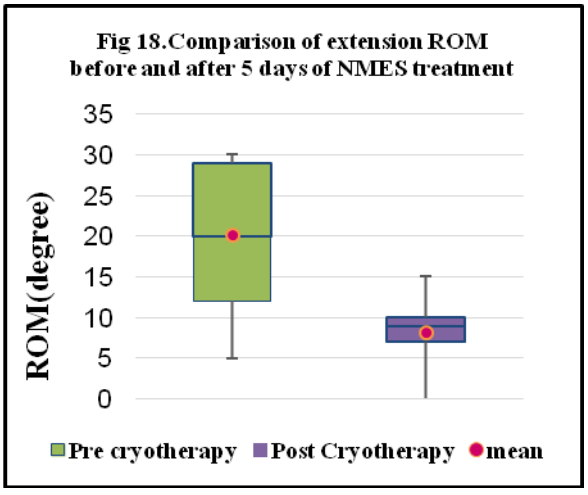
The above graph and table shows statistically significant reduction in pain post 5 days NMES treatment

Table 7:Comparison of flexion ROM within NMES group (Group B)			
Flexion ROM (degree)	**Pre intervention**	**Post 5 days intervention**	**p value**
Median±IQR	45±(7.5)	77±(26)	p<0.0001
Mean±(S.D.)	44.867±(10.494)	80.467±(17.246)	



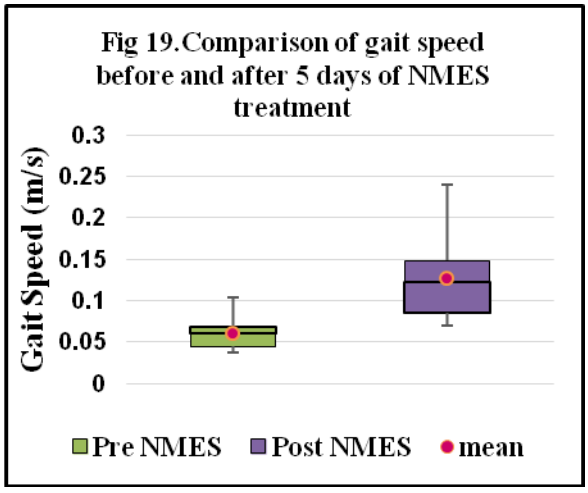
The above graph and table show statistically significant increase in flexion ROM, post NMES treatment

Table 8 :Comparison of extension ROM within NMES group(Group B)			
Extension ROM (degree)	**Pre intervention**	**Post 5 days intervention**	**P value**
Median±(IQR)	20±(17)	9±(3)	
Mean(S.D.)	20.2±(8.402)	8.2±(3.840)	P<0.0001



The above graph and table show statistically significant improvement in extension ROM post 5 days of NMES treatment

Table 9 :Comparison of gait speed within NMES group(Group B)			
Gait Speed (m/s)	**Pre intervention**	**Post 5 days intervention**	**P value**
Median±(IQR)	0.060±(0.023)	0.123±(0.063)	P<0.0001
Mean±(S.D.)	0.060±(0.018)	0.127±(0.049)	



The above graph and table shows statistically significant increase in gait speed post 5 days of NMES treatment

Comparison of between- group treatment techniques:

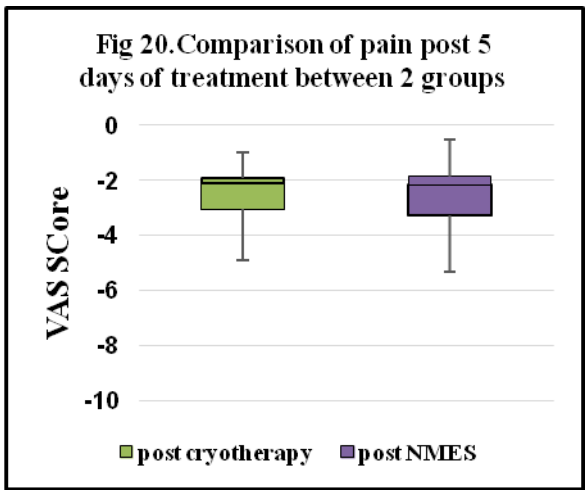
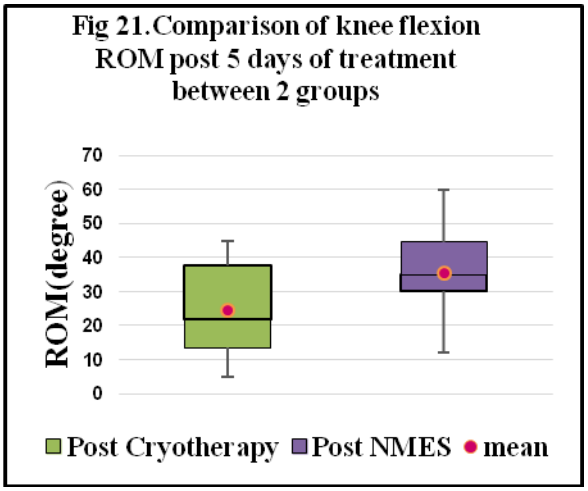


Table 10: Comparison of pain between cryotherapy (group A)and NMES group (Group B)			
Difference in Pain VAS score	**Group A (cryotherapy)**	**Group B (NMES)**	**p value**
Median±(IQR)	-2.1±(1.15)	-2.15±(1.4)	0.492

The above graph and table show no statistically significant difference in pain reduction between two groups

Table 11:Comparison of flexion ROM between cryotherapy group(group A) and NMES(Group B)			
Difference in flexion ROM (degree)	**Group A (cryotherapy)**	**Group B (NMES)**	**p value**
Median±(IQR)	22±24	35±(14.5)	p=0.0298
Mean±(S.D.)	24.533±(13.794)	35.6±(12.665)	



The above graph and table shows statistically significant increase in flexion ROM in NMES group compared to cryotherapy group.

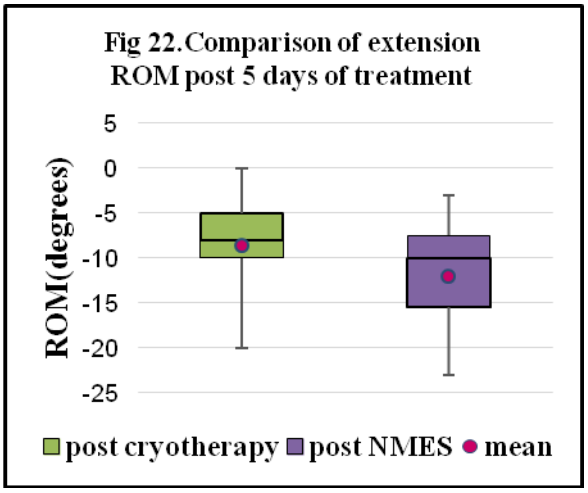
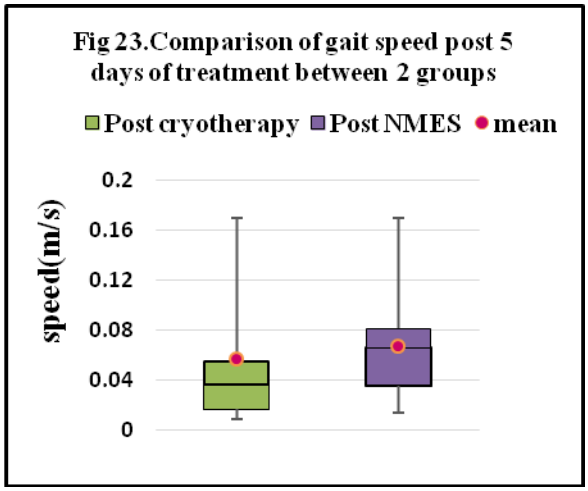


Table 12:Comparison of extension ROM between cryotherapy group (group A) and NMES (Group B)			
Difference in Extension ROM (degree)	**Group A (cryotherapy)**	**Group B (NMES)**	**P value**
Median±(IQR)	-8 ±(5)	-10±(8)	0.1202
Mean±(S.D.)	-8.533±(5.489)	-12±(6.071)	

The above graph and table shows no statistically significant difference in extension ROM between both treatment intervention groups

Table 13:Comparison of gait speed between cryotherapy group (Group A) and NMES(Group B)			
Difference in Gait Speed (m/s)	**Group A (cryotherapy)**	**Group B (NMES)**	**P value**
Median±(IQR)	0.037 ±(0.0385)	0.066 ±(0.046)	0.0759
Mean±(S.D.)	0.057±(0.076)	0.067±(0.039)	



The above graph and table show no statistically significant difference in gait speed between two groups.

DISCUSSION

In this study, the effects of two different non-invasive physical therapy interventions along with exercise therapy on knee joint pain, ROM and gait speed was studied. 30 patients who had undergone TKA were divided into 2 groups-out of which one group received cryotherapy and other group received NMES treatment.

The significant improvement achieved in range of motion and gait speed and reduction of pain because of cryotherapy can be explained as follows-

This result of cryotherapy treatment is in line with study by Eun-Kyung Noh in which cryotherapy and exercise significantly reduced pain and swelling in patients with TKA. [27] The reduction in inflammation and tissue metabolic rate by cryotherapy, helps in decreasing edema which helps in improving flexion ROM. [28] It also significantly improved extension ROM. Slowing effect on nerve conduction velocity of sensory afferent fibres also reduces pain. According to Hopkins, [29] cooling slows the discharge rate of mechanoreceptors of muscles and of the joint, so less information will be delivered to spinal cord in a given period of time, decreasing quadriceps inhibition post TKA surgery. Cryotherapy stimulates cutaneous receptors including mechanoreceptors

(pressure) and thermoreceptors, which excite I-a interneurons. It can counteract inhibition mediated through I-b interneurons, leading to excitation of quadriceps motor neuron pool. Thus, placing ice on effused knee results in disinhibition and also facilitation of motor neuron pool causing reduction in AMI.

According to Rice, [30] the effect of AMI on quadriceps strength causes decrease in knee extensor peak torque to decrease by 80-90%, 1-3 days after knee joint surgery. AMI slows strength gains during rehabilitation. It also slows gain in proprioception and increases susceptibility to further injury. [29]

Hence, Ewell in his study has stated that, reduction in AMI will cause better quadriceps volitional control and will help in effective strengthening of quadriceps muscle during rehabilitation process. [31] Improved quadriceps control and strength may have caused increased gait speed in patients with cryotherapy treatment. Further, Ewell has stated that focal knee joint cryotherapy treatment produced quadriceps facilitation for upto 45 and 60 minutes after initiation of treatment called "therapeutic window". Quadriceps strengthening within this time may benefit from increased activation of muscle.

The significant improvement achieved in range of motion and gait speed and pain reduction because of NMES can be explained as follows-

Reduced pain and increased ROM could be due to direct stimulation of muscle. [32] Study by Avramedis [22], has also found significant pain reduction, improved flexion ROM and reduced extensor lag on applying NMES from 2nd post-operative day.

is thought to alter motor recruitment by-preferentially activating greater pr oportion of larger type II muscle fibres and by providing more adequate training dose than through volitional exercises at comparable intensities. [9] Improved Quadriceps activation has led to decrease in edema which in turn decreases pain and increases ROM. As edema reduces, intra-articular pressure decreases. Afferent discharge from type III, IV fibres decreases, thus decreasing pain. Also muscle contraction effectively increases blood flow, causing washing away of nociceptors and increases nutrition to enhance healing of tissues. Afferent input from NMES may facilitate plastic changes throughout sensorimotor networks in CNS, ultimately enhancing motor control and strength.

Improvement in functional outcome measures 'Timed up and Go' test and 6 minute walk test distance, increased active knee extension was also found by Stevens Lapsley. [9] Improved gait speed post NMES treatment in TKA patients was also reported by Avramedis [22]. The increased gait speed may be due to improvement in quadriceps strength and increased participation in voluntary exercise program.

Effect of early active exercises in both the groups: Early active exercise is essential as it reduces healing time, increases structural strength, increases collagen synthesis in tendons, increases proteoglycan content in articular cartilage and helps in periosteal expansion of bone tissue. [29]

NMES produced significant improvement in flexion ROM as compared to cryotherapy. The possible reasons can be:

According to Ivy Man, NMES is used to reduce swelling in lower limb by improved activation of musculovenous pump. [33] Reduction in swelling leads to reduced pain and thus improved flexion ROM and extension ROM. This leads to improved Gait speed

Pain and swelling may cause reflex spasm of quadriceps muscle which may resist flexion ROM. So, apart from reducing pain and swelling by both treatment techniques, NMES may also cause reduced spasm of muscle leading to significantly increased flexion ROM

In this study there were however no significant differences between cryotherapy and NMES groups on effects of pain, extension ROM, improvement in gait speed. ROM for NMES group.

The probable reason can be due to similar effects of cryotherapy and NMES in reducing pain and increased quadriceps strength which leads to gait speed improvement.

CONCLUSION

i) Cryotherapy along with exercise therapy is effective in reducing pain, improving range of motion and increasing gait speed
ii) NMES along with exercise therapy is effective in reducing pain, improving range of motion and increasing gait speed.
iii) On comparison of effects of cryotherapy and NMES, NMES shows better results for improving knee flexion ROM. However, in terms of pain reduction, improving extension ROM and gait speed, both techniques are equally effective.
iv) This shows that early rehabilitation in acute phase is essential for improving mobility of the patient in long term.

LIMITATIONS:

- Pre-operative rehabilitation status was not same for all patients.
- Other factors like obesity was not considered which can affect gait speed.

CLINICAL IMPLICATIONS:

This study will help in framing early post-operative rehabilitation protocol early after TKA. Early reduction in post-operative pain and swelling will improve flexion and extension ROM. This will cause improvement in functional activities. It will also prevent long-term deficits in quadriceps strength deficit and prevent further complications of stiffness or arthrofibrosis, thus, reducing hospital stay.

ACKNOWLEDGEMENT(S)

I would like to thank all the patients for their co-operation.

Conflict of Interest: None

Source of Funding: None

Ethical Approval: Approved

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How to cite this article: Thosar JA, Parikh M, Desai MM. Comparison of effectiveness of cryotherapy and neuromuscular electrical stimulation (NMES) on pain, range of motion and gait speed in early post-operative phase in subjects with unilateral total knee arthroplasty. *International Journal of Research and Review*. 2021; 8(6): 245-259. DOI: *https://doi.org/10.52403/ijrr.20210630*

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