A Study to Evaluate the Effectiveness of Dynamic Neuromuscular Stabilization Exercises on Pain and Range of Motion Among Subjects with Knee Osteoarthritis

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Abstract

Background: Dynamic neuromuscular stabilization works on the stabilizing system of the spine with activation of the diaphragm with correct breathing pattern and enable the appropriate movement of the extremities. Knee osteoarthritis is degenerative joint disease and progressive loss of articular cartilage and is common in elderly that results to knee pain, knee stiffness, swelling and decreased strength. Dynamic neuromuscular stabilization is effective for knee pain, range of motion in subjects with knee osteoarthritis.
Methodology: A minimum 40 subjects, both male and female with knee osteoarthritis grade 2, grade 3 and grade 4 were selected for the study as per inclusion and exclusion criteria between age group of 40-70 years with 20 subjects in each group. Group A (Control group), Group B (Experimental group).Group A received transcutaneous electrical nerve stimulation (frequency:100hz,time duration: 20 min) ultrasound (frequency:1mhz,intensity: 1 W/cm^{2,} duration: 10 min) hydrocollator pack and isometric quadriceps exercises (10 repetitions,2 sets,10 seconds hold) Group B received Transcutaneous electrical nerve stimulation, ultrasound, hydrocollator pack, isometric quadriceps strengthening exercises and dynamic neuromuscular stabilization exercises(time duration:40 mins, repetitions:1/1 set). The baseline data recorded on the 1st day (pre-intervention) and 2nd week (post-intervention) and then on 4th week (post-intervention) for pain, range of motion. Total 24 treatment sessions on per subject given for 4 weeks i.e., 6 sessions per week. Results: Statistical analysis revealed that by the four weeks protocol, all two groups (Group A and Group B) showed significant improvements in pain reduction and increased range of motion.
Conclusions: The result of the study conducted that the application of DNS exercises with conventional exercises showed better improvement by 4 weeks exercise protocol in pain and range of motion on knee osteoarthritis.

Keywords: Knee osteoarthritis, Dynamic neuromuscular stabilization exercises, pain, range of motion

1.Introduction

Osteoarthritis is a chronic degenerative disease of joints with exacerbation of acute inflammation. It primarily affects the articular cartilage, subchondral bone, and synovial joint capsule and formation of new bone at the joint surfaces and margins. The term osteoarthritis was given by John Spendon. However, it is misnomer and the right term is osteoarthrosis or degenerative joint disease.[1] OA is one of the most common musculoskeletal disorder and oldest knee joint disease existed since prehistoric times. The prevalence of knee OA in India is higher in females than males, and is seen mainly above 40 years of age in females and 45 years of age in males. It affects the population of 2,693 of every 100,000 women and 1,770 of every 100,000 men.[2] The clinical manifestations are joint pain, stiffness, decreased range of joint movement, weakness of quadriceps muscles and alteration in proprioception. Decreased strength in the muscle groups involving the joints is significant because it causes the progressive loss of function. During movement, crepitation can be heard due to irregular joint surfaces caused by arthritis. Primary Osteoarthritis is due to an intrinsic alteration of the articular tissues themselves whereas Secondary Osteoarthritis is common in people with previous injury or fracture in knee joint. The knee is most common weight-bearing joint affected by OA , with the disease predominantly affecting the medial compartment of the tibiofemoral joint [3]. Cartilage is usually the first structure to be affected. Fibrillation which causes softening, splitting, and fragmentation of the cartilage occurs in both weight-bearing and non-weight bearing areas. Collagen fibres split and there is disorganization of the proteoglycan- collagen relationship such that water is attracted into the cartilage which causes further softening and flaking. Proliferation occurs at the periphery of the cartilage. Cystic activities form in the subchondral bone because eburnated bone is brittle and microfractures occur allowing the passage of synovial fluid into the bone tissue. Osteophytes form at the margin of the articular surfaces where they may project into the joint or into the capsule and ligaments. Bone of the weight bearing joints alters in shape- the tibial condyles become flattened.

Synovial membrane undergoes hypertrophy and becomes oedematous whereas capsule undergoes fibrous degeneration and chronic inflammatory changes. Ligaments become contracted or elongated.[4]

Dynamic neuromuscular stabilization (DNS) is an evolving concept in the field of rehabilitation that is based on the developmental kinesiology. It works on the entire stabilizing system of the spine along with the optimal activation of the diaphragm with correct breathing pattern enabling the appropriate movement of the extremities. This is given by professor Pavel Kolar after getting influence from the work done by Vojta on reflex locomotion (RL). The concept of reflex locomotion explains that specific involuntary motor reactions/ movement patterns are seen on giving firm pressure stimulation over certain zones in the muscles. These movement patterns are generic were termed global patterns. These patterns evoked from prone position is called "reflex creeping" while one from supine or side lying is called as "reflex rolling". These zones are generally derived from balance and stabilizing points during an infant development. Dynamic neuromuscular stabilization or DNS works on three basic principles:

- Developmental kinesiology
- Joint centration
- Core stabilization- Integrated spinal stabilizing system (ISSS) Developmental kinesiology is that development of human motor function in early childhood is genetically pre-determined and follows a predictable pattern. These motor patterns or programs are formed as the central nervous system matures, enabling the infant to control posture, achieve erect posture against gravity, and to move purposefully via muscular activity. Joint centration or neutral joint position occurs when joint surface congruency and muscles that support the joint are at their optimal mechanical advantage throughout

the range of motion and thus are able to produce varying forces according to the required skill. The centrated joint allows for optimal load transference of muscular forces across the joint and along the kinetic chain. The integrated spinal stabilizing system (ISSS) as described by Kolar, is comprised of balanced co-activation between the deep cervical flexors and extensors and upper thoracic region, as well the diaphragm, pelvic floor, all sections of the abdominals and spinal extensors in the lower thoracic and lumbar region.

These stabilizing systems provide spinal stiffness in coordination with intra- abdominal pressure, which serves to provide dynamic stability of the spine, this activation of core before movement is automatic providing stable base (punctum fixum) for the movement and known as "feed forward mechanism".[5] The DNS approach seeks to activate the ISSS and restore ideal IAP regulation in order to optimize efficiency of movement and to prevent overloading of the joints. DNS is rapidly gaining attention and acceptance in sports rehabilitation and performance for both the recovery from musculoskeletal overuse injuries and in injury prevention. DNS approach seeks to activate the ISSS and restore ideal IAP regulation in order to optimize efficiency of movement and to prevent overloading of joints. The DNS treatment approach is based on careful assessment of the quality of stabilization and or movement with the goal of restoring the ISSS via specific functional exercises based on developmental kinesiological positions exhibited by healthy baby. These exercises should activate the optimal patterns necessary for support in closed kinetic chains well as dynamic movements in the open kinematic chain, which occur during reaching, throwing, stepping forward or kicking. Each exercise must follow some basic principles.[6]

- Restore proper respiratory pattern and IAP regulation.
- Establish a good quality of support for any dynamic movement of the extremities.
- Ensure that all joints are well contracted throughout the movement.

2.Subjects and methodology:

2.1 Study design: Quasi-experimental study comparative in nature. Convenient sampling was done. The study was performed in the OPD of D.A.V Institute of Physiotherapy and Rehabilitation, Jalandhar. The duration of study was one and half years. A total of 40 subjects (male and female) were enrolled for the study and divided into two groups- group A and group B. Group A was Control group; Group B was Experimental group. Minimum of 20 subjects were allocated in each group.

2.2 Inclusion and Exclusion criteria:

Inclusion criteria for subjects who gave written informed consent form. Subjects in the age group between 40 to 70 years. Gender- both male and female were enrolled. Subjects with pain and stiffness in bilateral knees during weight bearing activities. Subjects diagnosed with primary knee osteoarthritis. Subjects with grade 2, grade 3, and grade 4 of knee osteoarthritis according to Kellgren and Lawrence classification.

Exclusion criteria: Subjects with previous surgery of hip and knee. Pre-diagnosed malignant disorders. Subjects with a recent history of lower limb. Subjects with neurological problems like stroke, Parkinson, multiple sclerosis, dementia. Seronegative arthropathies like rheumatoid arthritis, ankylosing spondylitis, psoriatic arthritis, reactive arthritis. Subjects who were not able to give written informed consent.

3. Procedure

A total 52 patients were approached during the study. Only 40 subjects, between the age group of 40 to 70 years, who met the inclusion and exclusion criteria, were recruited for the study. After explaining the procedure and the need for the study, written informed consent was obtained from all the subjects. The subjects with knee osteoarthritis were assessed by using numeric pain rating scale (NPRS), full circle goniometer, modified sphygmomanometer scale and Tinetti balance score. The subjects were assigned to 2 groups: Group A (Control group), Group B (Experimental group). The baseline data were carefully recorded at the 1st session (pre-intervention),4th session(post-intervention) and 6th session (post-intervention). A total 24 treatment sessions were given to each subject for 4 weeks (6 sessions per week). The total duration of each treatment session ranged from 35 to 40 minutes. Group A (control group) was given a Hydro collator pack, TENS, Ultrasound, and conventional exercises (quadriceps isometric exercises). Group B (experimental group) was given Dynamic neuromuscular stabilization exercises (DNS) along with a Hydro collator pack, TENS and conventional exercises (quadriceps isometric exercises).

3.1 Control group :

Quadriceps isometric exercises: Subjects asked to maintain supine lying position and rolled up towel placed under the knee. The subject asked to maximally activate the thigh muscles with 10 seconds hold, 10 repetitions and 2 sets. **Straight leg raise**: Subjects asked to maintain in supine lying position. Asked the subjects to lift up the leg up to 10cm from the plinth and hold for 10 sec in lifting phase, 10 repetitions and 2 sets.

Figure:1 quadriceps isometric exercise

Figure:2 Straight leg raise

3.2 Experimental group : • Dynamic neuromuscular stabilization: exercises was given to the subjects that involves 5 min warm up, 40 minutes DNS exercises and 5 minutes cool down, repetition 1 set. Warm up: Position of the patient: Patient seated on static cycling for 5 minutes. Position of the therapist: Therapist stands near to the patient.

Diaphragmatic breathing exercises:

- Learn and practicing diaphragmatic breathing at rest.

- Practice to maintain diaphragmatic breathing during maintaining basic DNS positions statically.

i.Baby rock (90-90 supine): patient lie in a supine position and maintained static movement while focusing on diaphragmatic breathing. They performed simultaneous single or double arm flexion and extension movements. Additionally, press a Swiss ball between both thighs while performing hip flexion and extension, promoting core stability and coordinated limb movements.

ii.Squat: patient asked to maintain standing position to perform the short-range squat while focusing on diaphragmatic breathing with (parallel hands next to the ear) with the feet hip width apart in front of a chair or stool, the knees were in flexed position.

The exercise performed with holding the dumbbell in both hands next to the ears in frontal + stretching loop around the thigh.

iii. Rolling: Subjects performed a stable position while focusing on diaphragmatic breathing and initiate controlled rolling movements to the right and left. With parallel straight arms, patient applied static pressure on a swiss ball held between both hands for 10 seconds. Additionally, a TheraBand loop with moderate to high resistance (blue, red, or black color) stretched around the thighs, promoting lateral stability and upper body strength.

iv. Side lying: Patient lie on their side, maintained a static position while concentrated on diaphragmatic breathing. They performed arm movements in various planes of motion while holding dumbbells and execute leg movements in the frontal plane while holding a TheraBand between the thighs. This exercise targets lateral stability, shoulder mobility, and hip abduction strength.

v.Prone: In the prone position, Patient focused on diaphragmatic breathing while pressed both forearms into the ground. They lift the upper trunk, achieving shoulder horizontal flexion while holding dumbbells, and performed hip hyperextension with extended knees. This exercise promotes spinal stability, shoulder strength, and gluteal activation.

Figure:3 diaphragmatic exercise

Figure:4 baby rock (90-90supine)

Figure:5 Squat

Figure:6 Rolling

Figure:7 Side lying

Figure:8 Prone

4. Results

This study aimed to evaluate the effectiveness of dynamic neuromuscular stabilization exercises on pain and range of motion among subjects with knee osteoarthritis. The statistical analysis was performed using SPSS software version 18.0. Level of significance 0.05 was used to determine the statistical significance. Both within Group and between Group analysis was done to analyse dependent variables [Score of numeric pain rating scale (NPRS) for pain and full circle goniometer for Range of motion. One way ANOVA and Post Hoc analysis by Tukey's method was used for the comparison of two groups. The data were collected on Day 1st (before the intervention), 2nd week (after the intervention), and 4th week (after the intervention). Statistical analysis between the Group showed that there was a statistically significant difference between two groups- Control group (Group A) Conventional exercises. Experimental group (Group B) Dynamic neuromuscular stabilization exercises in terms of pain and range of motion among subjects with knee osteoarthritis. Further on comparison of two groups- Control group (Group A) conventional exercises and experimental group (Group B) Dynamic neuromuscular stabilization exercises elicited that experimental group (Group B) was better than control group (Group A) in decreasing knee pain, and improving knee range of motion.

Table:1 Inter group analysis of group A and group B for NPRS readings (Pain Levels)

Unpaired T Test	NPRS					
	DAY1		2nd WEEK		4th WEEK	
	Group A	Group B	Group A	Group B	Group A	Group B
Mean	5.70	5.05	5.40	3.95	4.15	2.55
S.D.	0.801	1.395	0.995	1.468	1.268	1.572
Number	20	20	20	20	20	20
Maximum	7	7	8	6	6	6
Minimum	5	2	4	1	2	1
Range	2	5	4	5	4	5
Mean Difference	0.65		1.45		1.60	
Unpaired T Test	1.807		3.657		3.543	
P value	0.0786		<0.0018		0.0011	

Table Value at 0.05	2.02	2.02	2.02
Result	Not-Significant	Significant	Significant

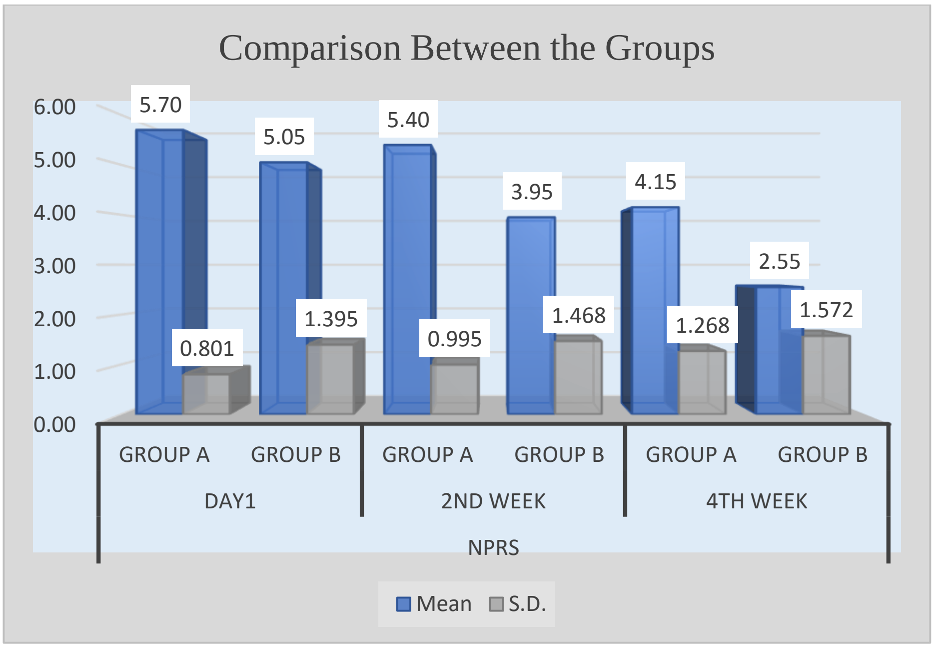

Figure:9 Inter group analysis of group A and group B for NPRS readings.

Table 1 and figure 9 shows the intergroup analysis of group A and group B for NPRS readings Using Unpaired T test . On Day 1, Group A reported a mean NPRS score of 5.70 while Group B recorded a slightly lower mean of 5.05. Although the mean difference was 0.65, the t-value (1.807) was below the critical value (2.02) and the p-value was 0.0786, rendering the result statistically non-significant. This indicates both groups started with comparable pain levels. However, by the 2nd Week, the pain levels significantly diverged — Group A had a mean of 5.40 and Group B 3.95, yielding a mean difference of 1.45. The t-value rose to 3.657 and the p-value dropped below 0.0018, indicating a statistically significant difference favouring Group B. The trend continued into the 4th Week, where Group A's pain reduced to 4.15 but Group B showed a more substantial decline to 2.55. With a mean difference of 1.60, the t-value was 3.543 and p-value 0.0011, again proving a significant advantage for Group B in pain reduction. Thus, DNS technique was more effective in improving pain intensity than Control group.

Table 2: Intergroup analysis of group A and group B for flexion ROM readings

Unpaired T Test	FLEXION ROM (degrees)

	DAY 1		2nd WEEK		4th WEEK	
	Group A	Group B	Group A	Group B	Group A	Group B
Mean	91.65	95.25	95.65	105.90	98.80	113.00
S.D.	10.484	13.026	10.864	13.014	9.780	15.166
Number	20	20	20	20	20	20
Maximum	105	120	110	125	110	130
Minimum	60	70	65	85	70	85
Range	45	50	45	40	40	45
Mean Difference	3.60		10.25		14.20	
Unpaired T Test	0.963		2.704		3.519	
P value	0.3417		0.0102		0.0011	
Table Value at 0.05	2.02		2.02		2.02	
Result	Not-Significant		Significant		Significant	

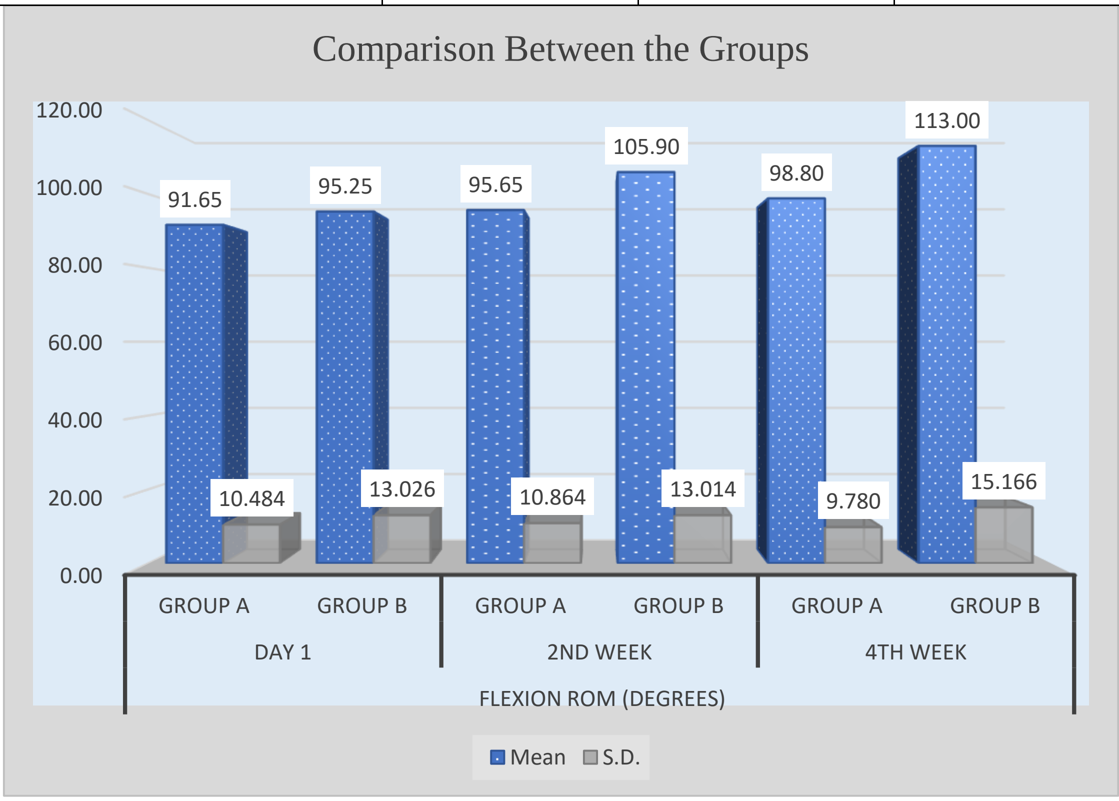

Figure: 10 Inter group analysis of group A and group B for Flexion ROM readings.

Table 2 and figure 10 shows intergroup analysis of group A and group B for flexion ROM readings that at baseline (Day 1), Group A had a mean flexion ROM of 91.65°, while Group B recorded 95.25°. The mean difference of 3.6° yielded a t-value of 0.963 (p = 0.3417), which was not significant, suggesting both groups began with similar mobility. However, by the 2nd Week, Group B showed marked improvement (105.90°) compared to Group A (95.65°), resulting in a mean difference of 10.25°, a t-value of 2.704, and a p-value of 0.0102 — a statistically significant difference. This disparity widened in the 4th Week, with

Group A improving to 98.80° and Group B reaching 113.00°. The mean difference here was 14.20°, with a t-value of 3.519 and p = 0.0011, clearly favouring Group B in flexibility and functional joint movement.

Table 3: Inter group analysis of group A and group B for Extension ROM readings.

Unpaired T Test	EXTENSION ROM (degrees)					
	DAY1		2nd WEEK		4th WEEK	
	Group A	Group B	Group A	Group B	Group A	Group B
Mean	5.05	2.75	4.20	1.00	2.90	0.50
S.D.	2.856	2.403	2.526	1.806	2.125	1.000
Number	20	20	20	20	20	20
Maximum	8	9	8	7	7	3
Minimum	0	0	0	0	0	0
Range	8	9	8	7	7	3
Mean Difference	2.30		3.20		2.40	
Unpaired T Test	2.756		4.609		4.570	
P value	0.0089		<0.0010		<0.0011	
Table Value at 0.05	2.02		2.02		2.02	
Result	Significant		Significant		Significant	

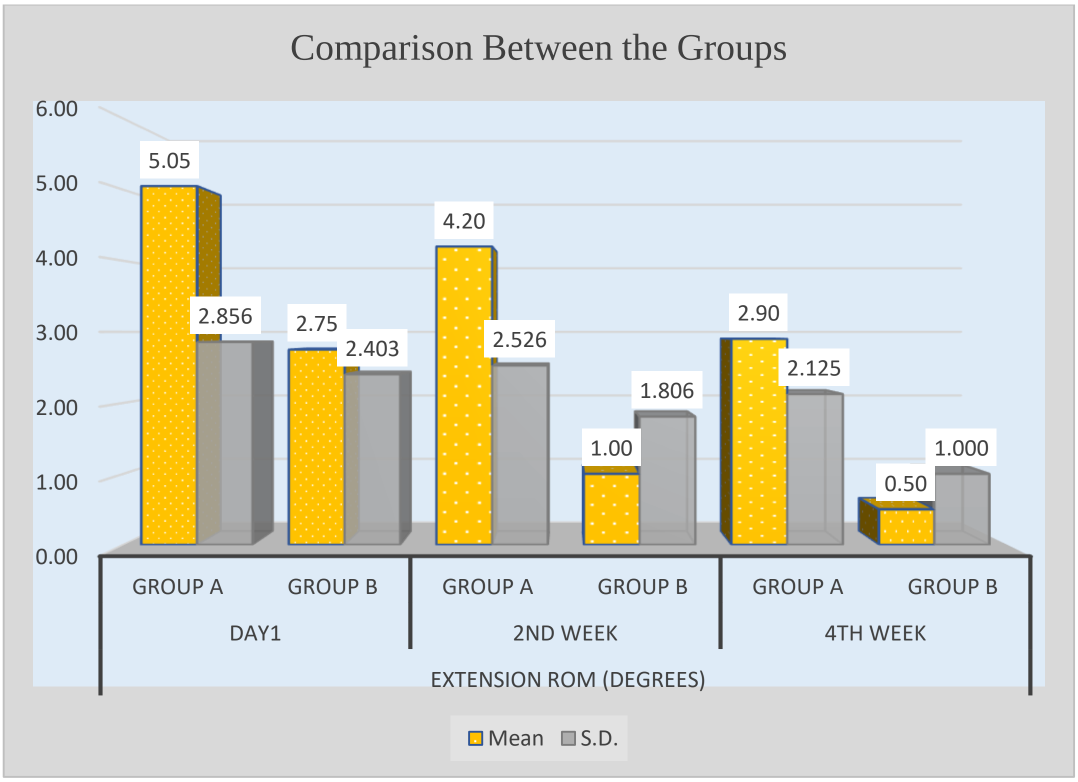

Figure:11 Inter group analysis of group A and group B for Extension ROM readings.

Table 3 and figure 11 shows inter group analysis of group A and group B for extension range of motion readings that For extension, lower values denote better range. On Day 1, Group A had a mean of 5.05° and Group B had 2.75°, indicating Group B already had better extension. The mean difference of 2.30° was statistically significant with a t-value of 2.756 and p = 0.0089. This trend amplified in the 2nd Week (Group A: 4.20°, Group B: 1.00°), with a mean difference of 3.20°, a t-value of 4.609, and p < 0.001 — a highly significant result. By the 4th Week, Group B nearly normalized (0.50°) while Group A reached 2.90°, with a 2.40° mean difference (t = 4.570, p < 0.0011), again strongly in favour of Group B showing DNS technique to be effective in improving knee extension range of motion.

5. Discussion:

The present study compared the effects of Dynamic Neuromuscular Stabilization (DNS) combined with conventional physiotherapy—hot packs, ultrasound therapy (UST), transcutaneous electrical nerve stimulation (TENS), and quadriceps isometric exercises—on pain and range of motion (ROM) in individuals with knee osteoarthritis. Both treatment approaches led to statistically significant improvements in pain levels, with conventional therapy showing greater early reductions due to the immediate effects of modalities such as TENS and heat. Nadler et al.[21] (2020) and Katz[22] (2010) reported that TENS significantly reduces pain through gate control mechanisms, while hot packs promote vasodilation and muscle relaxation, aiding in symptom relief (Knight et al.,[23] 1995). Despite these early improvements, DNS produced more sustained pain reduction over time by targeting deep stabilizer muscles and improving joint alignment and neuromuscular control, as supported by Kolar et al.[24](2013) and Janda & Kolar (2010). In terms of ROM, both groups showed significant gains, with thermotherapy, TENS, and ultrasound facilitating tissue extensibility and reducing stiffness (Sharma et al.,[25] 2015; Babu et al.,[26] 2018; Baker et al.,[27] 2012). However, the DNS group demonstrated greater improvements, especially in knee flexion, likely due to enhanced motor control and reduced compensatory movement patterns. Studies by Volejník et al.[28] (2015) and Lee et al.[29] (2022) highlighted that DNS improves joint mobility by restoring optimal movement patterns, activating deep core musculature, and promoting functional joint alignment. These findings suggest that while conventional physiotherapy is effective for symptom management, DNS offers additional benefits by addressing underlying movement dysfunctions and promoting long-term functional improvements in pain and mobility for individuals with knee osteoarthritis.

6. Future scope

Future studies could involve larger sample sizes across multiple cities to improve generalizability. Research may also focus on evaluating each intervention—such as DNS, TENS, ultrasound, or isometric exercises—independently. Additionally, similar studies could be applied to other muscle groups or joints, and extended to different populations, such as younger individuals or athletes, to assess the interventions' effectiveness in varied functional contexts.

7. Conclusion

The result of the study conducted that the application of DNS exercises with conventional exercises showed better improvement by 4 weeks exercise protocol when compared with conventional exercises alone in terms of Pain, range of motion on knee osteoarthritis. Hence this study supports alternative hypothesis.

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