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EFFECTIVENESS OF KINESIOTAPING (KT) COMBINED WITH PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION (PNF) OVER AFFECTED DORSIFLEXORS ON ANKLE RANGE OF MOTION (ROM), BALANCE ABILITY AND MOBILITY IN SUBJECTS WITH SUB-ACUTE STROKE.

Physiotherapy & Rehabilitation

Dr. G. B. Durga MPT 2nd year neurology, College of physiotherapy, SVIMS, Tirupati.
Dr. G. Kameswari* MPT (Neurology), College of physiotherapy, SVIMS, Tirupati. *Corresponding Author
Dr. V. Srikumari MPT (Neurology) PhD, Associate professor, College of physiotherapy, SVIMS, Tirupati.
Dr. K. Madhavi MPT (CT), PhD, professor & principal, college of physiotherapy, SVIMS, Tirupati.

ABSTRACT

Background And Purpose: Stroke is defined as an abrupt onset of a focal neurological deficit and is a leading cause of prolonged disability and death worldwide.[1] As there is limited evidence available on KT combined with PNF (KT-PNF) with inconsistent conclusions, previous studies suggested for large randomized control trails with varied methodology for examining the consistency in the resultant findings. The purpose of the study is to evaluate the effectiveness of KT-PNF over affected dorsiflexors on ankle ROM and balance ability in subjects with sub-acute stroke. **Objectives:** To determine the effectiveness of KT-PNF over affected dorsiflexors on ankle ROM, balance ability and mobility by using Universal goniometer, Berg balance scale (BBS) and Time up and go test (TUGT) in subjects with sub-acute stroke. **Materials And Methods:** A study was conducted, in which 30 subjects were randomly allocated into group-A and group-B. The subjects gave their consent before the study. In the experimental group, the subjects received KT-PNF along with conventional therapy, while the control group received conventional therapy which includes cryotherapy, electrical stimulations, and therapeutic exercises. The study was conducted over a period of 3 weeks, with a total of 12 sessions. Pre-test and post-test evaluations were done to measure ankle dorsiflexion ROM (DF-ROM), balance ability and mobility using a universal goniometer, BBS and TUGT. **Results:** After 3weeks of the treatment period, the subjects in the experimental and control groups had shown improvement with outcome measures. Comparing both groups, there is a significant improvement in the experimental group, for ankle DF-ROM (t=24.6, p=0.0001), BBS (t=12.88, p=0.0001) and TUGT (t=8.76, p=0.0001). **Conclusion:** This study found that KT-PNF along with conventional therapy has shown a positive effect on ankle DF-ROM, balance ability and mobility in sub-acute stroke subjects.

KEYWORDS

Stroke; Kinesiotaping; Proprioceptive neuromuscular facilitation; Range of motion; Balance, Mobility.

INTRODUCTION:

STROKE is defined as an abrupt onset of a focal neurological deficit which can cause prolonged disability or even death worldwide.[1] It is one of the most common cerebrovascular diseases, which can include cerebral infarction, intracerebral haemorrhage (ICH), and subarachnoid hemorrhage (SAH).[2] In India, the most common risk factors for stroke are obesity, diabetes mellitus, alcoholism, hypertension, and a sedentary lifestyle.[3]

The foot and ankle plays an important role in walking by providing momentum, shock absorption and balance control.[4]A spastic foot is characterized by foot drop, which refers to the inability to raise front part of the ankle and toes, resulting in decreased ankle range of motion. It is typically caused by common peroneal nerve or muscle damage, brain/spinal disorders. This can cause the bodyweight to shift towards the non-paretic side, leading to an asymmetric weight distribution and reduced balance[5] Deficits in foot and ankle proprioception can also impair balance.[6]Balance impairment is one of the common problem in stroke subjects that affects their activities of daily life.[2] Physiotherapy can help to manage foot drop through electrical stimulations, stretching's, ankle foot orthosis (AFO), and strengthening exercises.[5]

KT has become an adjunct treatment to rehabilitation programs for various conditions.[5] It was introduced by Kenzo Kase and involves applying appropriate tension along elastic therapeutic tape while stretching the target muscle.[2] Main benefits of kinesiotaping is its low cost and easy application.[5] It can be used to support weak muscles, relax overstretching muscles, reduce pain, control muscle tone, increase range of motion, and improve balance.[2]

Spasticity is a common complication of stroke that can negatively affect the balance. It occurs when there is an imbalance of inhibitory and excitatory impulses in the body. A study by Wissel et al. found that 25% of stroke subjects experience spasticity within the first six weeks after the stroke. Spasticity usually affects the elbow (79% of patients), wrist (66%), and ankle (66%).[7] After the stroke, spasticity in the lower limbs especially can increase the stiffness of the muscles and fascia around the joints and decreases the ROM.[8]

Balance refers to the ability to maintain body orientation in both static and dynamic conditions. Postural stability at rest and in response to active movement or external perturbations are the respective categories of these conditions. The human body relies on a composite sensorimotor-control system that coordinates body segments through feedback and feed-forward strategies.[9]

Mobility refers to the capability of a person to move and control their body position. The process of physical mobility requires adequate muscle strength, energy, skeletal stability, joint function, and neuromuscular coordination. Any factor that affects this process can result in limited mobility. There are several physical and psychological factors that can cause immobility. Mobility can also be adversely affected by several traumatic injuries, neurological and musculoskeletal disorders, such as cerebral palsy, multiple sclerosis, and Parkinson's disease.[10]

NEED OF THE STUDY

- Foot drop is a common consequence of stroke, with an incidence rate as high as 20 to 30 percent. It is characterized by an ankle joint that cannot dorsiflex, resulting in cross-threshold gait while walking. The ankle joint is the centre of adjustment for human walking posture and stability.
- The dorsiflexion function plays a crucial role in gait. Abnormal dorsiflexion function can affect the angle of hip flexion and knee flexion, leading to asymmetrical gait and decreased pace. Foot drop can limit a person's ability to perform daily activities and their independence. Reduced ankle ROM due to dorsiflexor spasticity can affect their balance, posture and walking patterns.
- There is limited research available on KT-PNF, and the conclusions drawn from the studies are inconsistent. Thus, there is a need for large randomized control trials to examine the consistency in the findings. Systematic reviews have presented KT application in various methods and durations ranging from 1 day to 12 weeks. Moreover, it is essential to examine the relative efficacy of different treatment dosages in KT application and optimize the treatment program to best suit the patient's needs.

OBJECTIVES:

1. To determine the effectiveness of KT-PNF over affected dorsiflexors on ankle ROM by Universal goniometer in subjects with sub-acute stroke.

2. To determine the effectiveness of KT-PNF over affected dorsiflexors on balance ability by BBS in subjects with sub-acute stroke.

3. To determine the effectiveness of KT-PNF over affected dorsiflexors on mobility by TUGT in subjects with sub-acute stroke.

MATERIALS AND METHODS

Materials

- High couch and pillows
- Adhesive elastic tape (kinesiology 3NS tape)
- Electrical stimulator with all its accessories
- Ice pack (5-10˚)
- Universal goniometer, Cones-2, Inch tape
- Stop watch, Standard Chair, Stepper, Yard stick

Methods

A total of 30 sub-acute stroke subjects were selected from SVIMS-College of physiotherapy, general ward, neurology, and SVAYCH in Tirupati based on study's inclusion criteria. After obtaining their consent for participation, subjects were randomly divided into two groups – experimental group (group-A) and control group (group-B). Experimental group received KT-PNF and conventional therapy, while control group received conventional therapy alone after being provided with an explanation of the contents and purpose of this study.

Study Design: Prospective randomized control design

Sampling Technique: Purposive sampling

Sample Size: 30 (15 in each group)

Study Setting: SVIMS-College of Physiotherapy, General ward, Neurology and SVAYCH.

Study Duration: Each session treatment was for 1 hour, 4 times per week, with 12 Sessions, for a total duration of 3 weeks.

Study Period: From March 2023 to November 2023

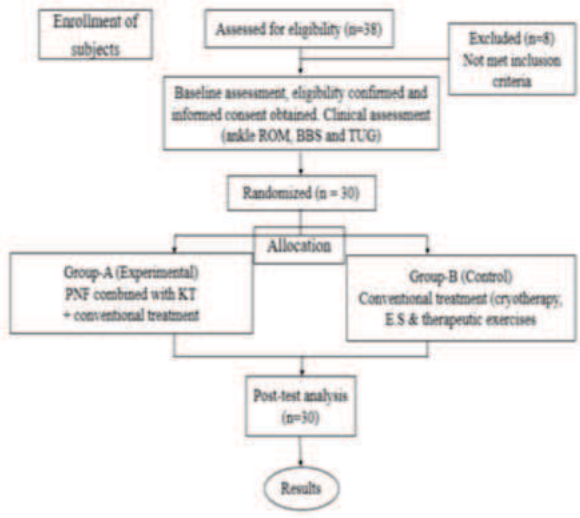
Inclusion Criteria

- Post stroke of sub-acute subjects. (1-3 months)
- Both ischemic and hemorrhagic stroke subjects.
- Age group of 40-60 years.
- Both male and female stroke subjects.
- Mini-mental scale examination score > 24.
- Affected limb dorsiflexor spasticity with MAS score of <2 or =2.
- Berg balance scale (BBS) score >35-45
- Able to stand independently for at least 1 minute without assistive devices.

Exclusion Criteria

- Stroke subjects with cognitive and perceptual deficits, neurological deficits and sensory deficits.
- Bilaterally affected limbs.
- Recurrent stroke
- A premorbid / current orthopaedic problem involving the lower extremities and spine that could affect balance.
- Any ankle damages or surgeries.
- Vertigo, dizziness and balance related disorders.
- Acute and Chronic stroke subjects.

Study Algorithm



Interventions

Experimental Group

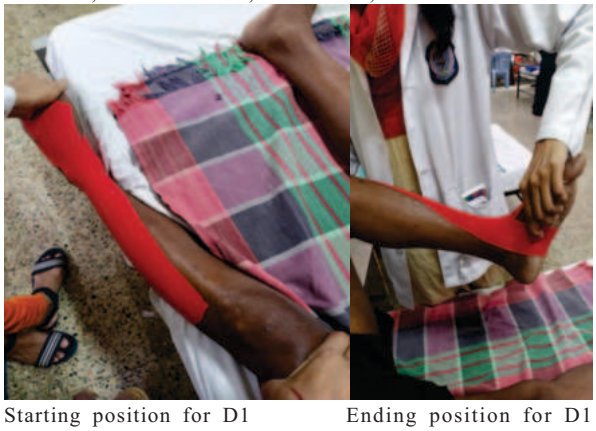
Method of KT Application:

Position of the patient	:	Supine lying, subjects were positioned on a high couch to prevent the feet from touching the ground.
Type of KT	:	Adhesive elastic tape (kinesiology 3NS tape).
Direction of pull	:	Muscle activity is facilitated from origin to insertion using proximal to distal for weak muscles at 15-35% tension
Location of KT	:	Over tibialis anterior, extensor hallucis longus (EHL), extensor digitorum longus (EDL) muscles.
Duration of KT	:	Replaced every other day, for 3 weeks.

Three I-strips of kinesiotape were used. The first strip was placed at the origin of EHL and stretched by approximately 30% over its original length. It was then applied along the anterior part of shin of the tibia and ended at base of the distal phalanx of the big toe. Similarly, the second strip was placed at the origin of EDL and was stretched in the same way as first strip. It was then applied along the shin of the tibia and ended at the phalanges of the lateral four digits. Finally, the third strip was placed at the origin of the tibialis anterior and was applied along the shin of the tibia and ended at the anteromedial surface of the medial cuneiform. After application of KT, PNF diagonal patterns of contract-relax technique was used.

PNF Lower Extremity D1 Flexion/Extension Pattern

- Starting position: Hip extension, abduction, and internal rotation, ankle plantarflexion, foot eversion, and toe flexion.
- Hand Position: One hand placement was on the distal anterior-medial aspect of the thigh, and the other hand was placed on the medial aspect of the dorsal surface of foot.
- Ending Position: Hip flexed, adducted, and external rotated, knee flexed, Ankle dorsiflexed, Foot inverted, Toes extended.[11]



Starting position for D1 extension pattern | Ending position for D1 flexion pattern

Figure 1: D1pattern

Starting position for D2 extension pattern | Ending position for D2 flexion pattern

Figure 2: D2 patterns

PNF Lower Extremity D2 Flexion/Extension Pattern

- Starting Position: Hip extended, adducted, and external rotated, Ankle plantarflexed, Foot inverted, Toes flexed.

- Hand Position: Hand on distal anterior-lateral thigh, Hand on lateral aspect of dorsal surface of the foot.
- Movements to Ending Position: Hip flexed, abducted, and internally rotated, knee flexed, Ankle dorsiflexed, Foot everted, Toes Extended.
- Each pattern of the PNF technique is performing for 5 minutes and a 3 minutes rest interval is providing between the different patterns.[11]

Control Group

Conventional Treatment

- **Cryotherapy for dorsiflexors:** The patient was positioned in supine lying. An ice pack was placed under the plantar flexors for 10-15 minutes.
- **Electrical stimulation:** It is a method that involves using electrical impulses to stimulate muscle contractions.[12]
- **Procedure:** Subjects were given instructions and checked for the contraindications and treatment was further proceeded. After proper checking of the apparatus, preparation of the apparatus and trays was done.
- **Position of the patient:** A low couch was used to position the patient in a supine lying, with their ankle being supported by a sandbag to keep in a neutral position.
- **Group of muscles:** Ankle dorsiflexors and Evertors.
- **Type of current:** Surged faradic current.
- **Parameters:** Pulse duration: 0.1to 1ms, Surge duration: 4sec, Rest interval: 6 sec, Treatment duration: 15 minutes.

Table 1: Therapeutic Exercises

Therapeutic exercises[13]	No. of times & duration
Stage 1: Ankle joint mobility improving and muscle strengthening exercise. Promote ankle joint range of motion in sitting position. Repeat ankle joint flexion and extension. Repeat ankle joint dorsiflexion and plantarflexion.	20times/10mins 5times/3mins 5times/2mins 10times/5mins
Stage 2: Weight bearing exercise in static standing position. Repeat the motion of moving the affected side weight in a sitting position and standing up. Move the weight in diverse directions in standing position.	20times/10min 10times/5mins 10times/5mins
Stage 3: Weight movement and task training in a standing position on 1 foot. Raise non-affected side foot in a standing position. Diverse affected side weight movements in a standing position on 1 foot. Upper extremity task training in standing on 1 foot.	20times/10min 5times/2mins 10times/5mins 5times/3mins

Statistical Analysis

- The statistical analysis was performed using the "SPSS 26 version" software. The data was first entered into a Microsoft Excel spreadsheet, tabulated, and then subjected to statistical analysis.
- All 30 participants completed the study protocol within three weeks of treatment period. The demographic data was analysed using the chi-square test. Paired t-tests were used for within group analysis, whereas unpaired t-tests were used for between group analysis, with outcome measures of universal goniometer, BBS, and TUGT.

RESULTS

Table 2: Within Group Analysis Of Pre And Post-test Values Of Ankle DF-ROM, BBS And TUGT In Experimental Group

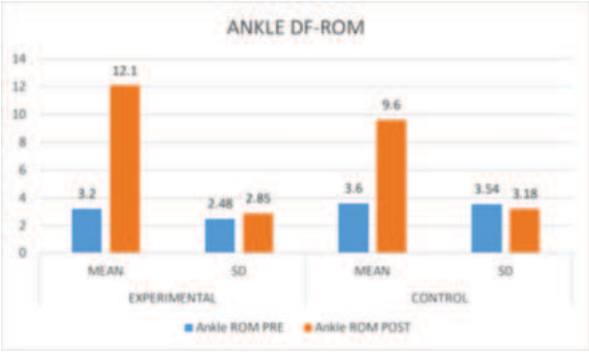
Experimental group		N	Mean	SD	t-value	p-value
Ankle DF-ROM	Pre	15	3.2	2.48	24.06	0.0001
	Post	15	12.1	2.85		
BBS	Pre	15	38.27	2.55	12.88	0.0001
	Post	15	47.2	2.596		
TUGT	Pre	15	34	8.332	8.76	0.0001
	post	15	19.7	9.94		

In experimental group, the mean and standard deviation values for ankle DF-ROM were 3.2±2.48 and 12.1±2.85 respectively before and after intervention. The BBS scores were increased from 38.27±2.55 to 47.2±2.59. The TUGT scores were decreased from 34±8.33 to 19.7±9.94.

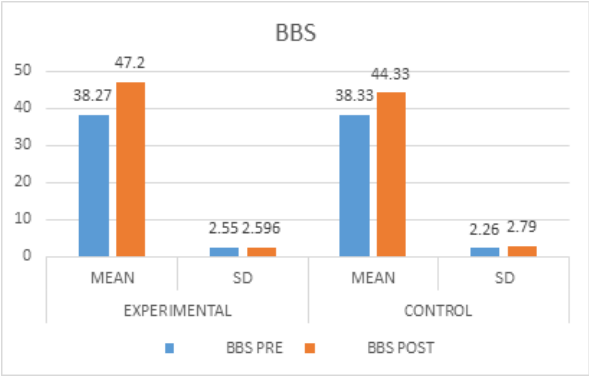
Table 3: Within Group Analysis Of Pre And Post-test Values Of Ankle DF-ROM, BBS And TUGT In Control Group

Control group		N	Mean	SD	t-value	p-value
Ankle DF- ROM	Pre	15	3.6	3.54	25.1	0.0001
	Post	15	9.6	3.18		
BBS	Pre	15	38.33	2.26	17.75	0.0001
	Post	15	44.33	2.79		
TUGT	Pre	15	34.8	13.2	11.79	0.0001
	Post	15	27.8	12.46		

In control group, the mean and standard deviation values for ankle DF-ROM were 3.6±3.54 and 9.6±3.18 before and after the intervention respectively. The BBS scores increased from 38.33±2.26 pre-test to 44.33±2.79 post-test. The pre and post-test values of TUGT were 34.8±13.2 and 27.8±12.46, respectively.



Graph1: Graphical Representation Shows The Comparison Of ANKLE DF-ROM With Mean And SD Of Pre And Post-values In Two Groups.



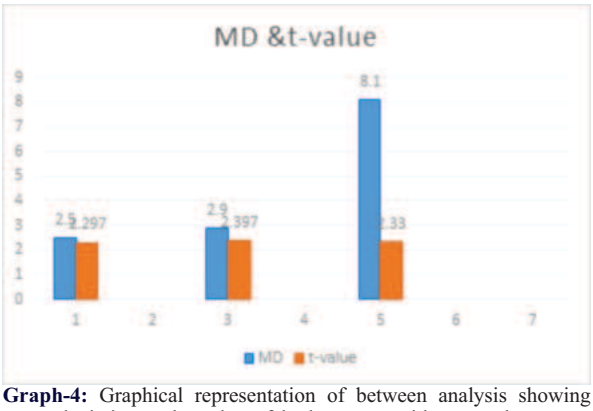
Graph2: Graphical Representation Shows The Comparison Of BBS With Mean And Sd Of Pre And Post-values In Two Groups:

Graph-3: Graphical Representation Shows The Comparison Of TUGT With Mean And SD Of Pre And Post-values In Two Groups.

Table 4: Between Group Analysis Of Both Control And Experimental Group Of Ankle DF-ROM, BBS And TUGT Of Post-test Values

Variables	Group	N	MD	t-value	p-value
ANKLE DF-ROM	Control	15	2.5	2.297	0.02
	Experimental	15			
BBS	Control	15	2.9	2.397	0.02
	Experimental	15			
TUGT	Control	15	8.1	2.33	0.02
	Experimental	15			

- Both groups had similar pre-values. To compare the results between two groups, we used an unpaired t-test for post analysis. The mean difference of ankle DF-ROM values between two groups are analysed. The results showed a t-value of 2.297 and a significance level of 98%, indicating that the difference was statistically significant (p-value = 0.02).
- The mean difference of BBS values between both groups are analysed. The results showed a t-value of 2.397, and a significance of 98%, indicating statistical significance with a p-value of 0.02.
- The mean difference of TUGT values between two groups are analysed. The results revealed a t-value of 2.33 and a significance of 98%, indicating that there is a statistical significance with a p-value of 0.02.



Graph-4: Graphical representation of between analysis showing mean deviation and t-value of both groups with pre and post-test values:

DISCUSSION

- Foot drop can significantly limit a person's ability to carry out daily activities. A reduced DF-ROM due to spasticity can also affect one's posture, balance and walking patterns. The primary objective of the study was to examine the effectiveness of KT-PNF over the affected dorsiflexors on ankle ROM, balance ability and mobility in subjects with sub-acute stroke.
- Spasticity is a condition that can occur in UMN lesions. Due to the spasticity of plantarflexors, the ankle DF-ROM, balance and mobility were reduced. Balance is a crucial component of all the movements. Maintaining balance is a complex task that involves the coordination of multiple systems.
- The AFO is a commonly used orthosis for foot drop. It is lightweight, detachable and easy to wash. According to Bulley et al. (2011), the use of an AFO can result in a fixed ankle, leading to an abnormal gait pattern and weakening of surrounding muscles. Therefore, it does not provide long-term relief from foot drop symptoms. [4] Whereas KT provides stability around the joint, it works by triggering gamma motor reflexes of the skin, which allows for continuous muscle contraction and relaxation. This, in turn, increases the space between muscle and skin, improves blood and lymph circulation, increases joint movement, and enhances muscle activation and re-education. The overlapping of KT can also increase stability.[14]
- After KT application for TA, EHL and EDL, PNF diagonal patterns with contract-relax technique were used. The underlying mechanism include autogenic inhibition, reciprocal inhibition and successive induction. It helps to increase range of motion, muscle strength, balance, and fine motor control.[15]
- After application of PNF techniques in rehabilitation, motor function recovery involves relearning motor skills through a process called neuroplasticity. It refers to the ability of CNS to undergo structural and functional changes in response to new experiences. This process involves neuroanatomical, neurochemical, and neuroreceptive changes. At first, learning-related plasticity strengthens existing neural connections and forms new ones that support learned behaviors. As the process continues, neural connections become more focused, and skill and preferential pathways develop.[7]
- According to a study conducted by Park and Bae in 2021, PNF-KT can improve ankle DF-ROM and balance ability in subjects with chronic stroke. The researchers used a wearable sensor called iSen to measure ankle DF-ROM and found that improvement was statistically significant with a p-value of less than 0.001.[5] Present study also revealed similar effects on ankle DF-ROM in the experimental group with significant improvement with a p-value of 0.0001
- In 2015, Bae Y-H, Kim HG, Min KS, and Lee SM conducted a study on the effects of lower leg KT on balance ability in stroke subjects with foot drop. The study found that temporary KT had a positive impact on stationary balance in stroke subjects. The BBS score showed significant improvement with a p-value of less than 0.05.[4] In the current study, we observed that the BBS score of the experimental group improved significantly with a p-value of 0.0001
- In 2020, Kim K-H and Lee Y-J conducted a study to assess the immediate effects of KT on mobility and balance ability in subjects with chronic hemiparesis. The results showed significant improvement in TUGT with a p-value of 0.026.[16] Our current study findings indicate that there was significant improvement in the TUGT component of the experimental group, with a p-value of 0.0001
- Based on the statistical analysis, both groups showed significant differences between the pre and post-values of ankle DF-ROM, BBS and TUGT. However, the experimental group showed a better improvement compared with control group.

CONCLUSION

According to this study, using KT-PNF along with conventional therapy proved to be more effective than using conventional therapy alone in subjects with sub-acute stroke. The optimal location and duration of the KT were clearly mentioned to ensure that the treatment program was tailored to specific dosage. Therefore, KT-PNF can be considered as one of the effective and an alternative therapeutic option to improve the ROM and balance ability during rehabilitation in subjects with sub-acute stroke.

Limitations

- The study had a smaller sample size.
- No further follow-up was conducted.
- There was no instrumentation used to record joint position sense.

Recommendations

- Further studies should have a larger sample size.
- Further follow-up should be conducted.
- Further research is necessary to confirm changes in joint position sense and observe improvements in static balance.

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