DOI: 10.7860/JCDR/2026/78296.23416

Original Article

Physiotherapy Section

Effectiveness of Mulligan SNAG Mobilisation on Muscle Activation, Pain, Disability and Sleep Quality in Acute Neck Pain: A Randomised Controlled Trial

UZMA SAYYAD[1], SHAGOOFA MUSSTAQ[2], ASHI SAIF[3]

ABSTRACT

Introduction: Neck pain is a disabling problem faced frequently by people across the globe and acute neck pain is more prevalent among the adult age group due to posture abnormalities and dysfunctions. It is necessary to establish the treatment strategies that can help reduce the overall disability and functional impairments and impact the sleep quality.

Aim: To determine the effect of Mulligan Sustained Natural Apophyseal Glide (SNAG) mobilisations on Electromyographic (EMG) activity of neck muscles (upper trapezius and splenius capitis), sleep quality, neck disability, pain and pain pressure threshold in subjects with acute neck pain and compare it with conventional rehabilitation.

Materials and Methods: A single-blinded randomised control trial was carried out with a sample of 32 subjects, recruited from the Department of Centre for Physiotherapy and Rehabilitation, Jamia Millia Islamia, New Delhi, India from October, 2018 to March, 2019. The study included adults (male and female) aged 18-40 years with acute neck pain lasting ≥4 weeks, Numeric Pain Rating Scale (NPRS) score ≥6, and symptoms reproduced by neck motion. Participants were divided into two groups (n=16 in each group). Subjects in Group-1 were given intervention for neck pain in the form of Mulligan SNAG mobilisation along with cervical stabilisation exercises three times per week for four weeks. Subjects in Group-2 received only cervical stabilisation exercises three times per week for four weeks. For investigating the effect of the two interventions on EMG activity of neck muscles, sleep quality, neck disability, pain and pain pressure threshold, repeated measures Analysis of Variance (ANOVA) was applied for parametric variables and Wilcoxon Signed-rank Test was used to establish the within group difference of non parametric variables. Level of significance was set at $p<0.05$.

Results: The result indicated that both the treatments improved the parameters. Group×Time interaction was found to be significant ($p>0.05$) in splenius muscle activity and group effect was significant ($p>0.05$) in pain pressure threshold, However, significant time effect was seen in all the variable ($p>0.05$).

Conclusion: The present study concludes that Mulligan SNAG mobilisation can be used as an adjunct to conventional exercise programmes to improve subjective sleep quality parameters, neck extensor muscle activity, neck disability, pain and pain pressure threshold in patients with acute neck pain.

Keywords: Electromyography, Pain pressure threshold, Sustained natural apophyseal glide

INTRODUCTION

The Global Burden of Disease (GBD) Study 2010 defines neck pain as "pain in the neck with or without pain referred into one or both upper limbs that lasts for at least one day" [1]. GBD 2015 identifies neck pain as the leading cause of disability globally, particularly in high-income countries. It ranks 19th in global Disability-Adjusted Life Years and remains a growing issue [2]. Neck pain can be disabling and costly [3] and is categorised into four types: 1) neck pain with mobility deficits; 2) neck pain with headache; 3) neck pain with radiating pain; and 4) neck pain with movement coordination impairments.

Blanpied PR et al., suggested that acute idiopathic neck pain with mobility deficits and no radiculopathy can be confirmed through history-taking and clinical manoeuvre [4]. Diagnostic tools include pain assessment, cervical Range Of Motion (ROM), Cervical Flexion Rotation Test (CFRT), Spurling's test, distraction test, Valsalva maneuver and Upper Limb Tension Test (ULTT) to differentiate non radicular pain from radiculopathy. Neck pain sources include muscles, zygapophyseal joints and discs, with pathophysiology often linked to facet joint stimulation. Pain referral patterns vary by cervical level, such as C2-3 pain referred to the head and C6-7 pain to the scapula [5]. Examination reveals central/unilateral pain, limited ROM, end-range pain and restricted cervical/thoracic mobility. CFRT and intersegmental mobility tests aid diagnosis, along with pain pressure threshold assessments using an algometer [6].

Neck pain affects global health, causing pain, tenderness, disability and sleep disturbances, which impair individual performance. Poor sleep increases the risk of chronic pain and worsens pain prognosis, while improved sleep aids recovery [7]. Sleep parameters, excluding duration, correlate with reduced pain tolerance [8]. Recovery from acute idiopathic neck pain can take 6-12 weeks [9]. Common treatments include analgesics, rest and referral to physical or manual therapy [10]. Mobilisation, such as Mulligan SNAG, improves neck mobility [11,12]. Passive mobilisation stimulates joint receptors, enhancing segmental activity [13,14]. Stabilisation exercises combined with manual therapy improve pain, disability, ROM, quality of life and pain pressure threshold [15].

It is crucial to establish effective treatment strategies to reduce disability, improve sleep and assess muscle activity post-intervention. While exercise therapy is central to conservative management, the role of Mulligan SNAG mobilisation in muscle activity, pain and sleep disturbances requires further research.

The present study aimed to evaluate Mulligan SNAG mobilisation's efficacy in acute neck pain regarding EMG activity, sleep quality, pain pressure threshold and disability. The null hypothesis assumes that Mulligan SNAG mobilisation combined with conventional exercises will have no significant effect on EMG activity, sleep

quality, neck disability, pain, or pain pressure threshold in patients with acute neck pain. Conversely, the experimental hypothesis posits that this intervention will produce significant improvements in these outcomes.

MATERIALS AND METHODS

The present study was a parallel group, comparative pre-test post-test single-blinded randomised control trial, completed at the Department of the Centre for Physiotherapy and Rehabilitation Sciences, Jamia Millia Islamia, New Delhi, India spanning between October, 2018 to March, 2019.

The subjects of the study were informed about the purposes of the study and about procedures which they would be undergoing and verbal consent as well as a signed consent form was obtained. The study conforms to the principle set by the Declaration of Helsinki (1964) and its updates. The present study has been approved by the Institutional Human Ethical Committee, Jamia Millia Islamia (31/10/184/JMI/IEC/2018).

Sample size calculation: Sample size for the study was established using the Software G. Power 3.1.9.2 on the data of Shin EJ and Lee BH in which Mulligan SNAG mobilisation was used as an intervention for pain, with the effect size of 1.3, alpha level of 0.05 and power (1-beta) of 0.95 [16]. The sample size was calculated to be 32 to allow 15% of dropouts.

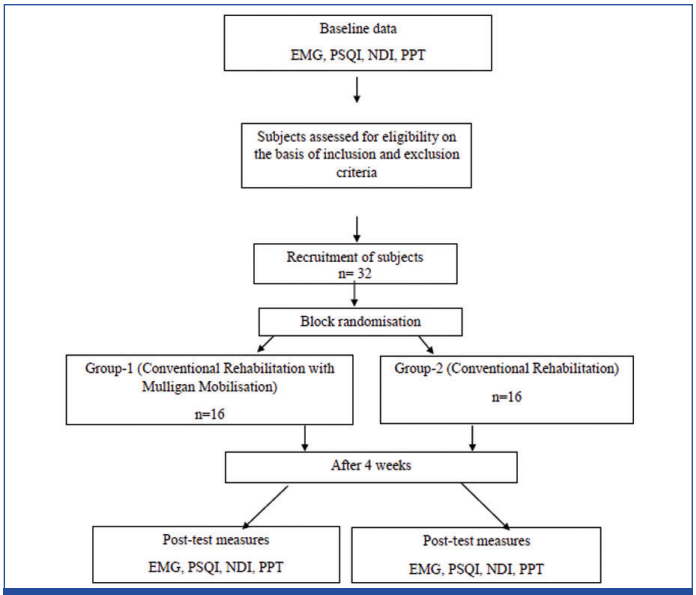
Inclusion criteria: Individuals having neck pain for four weeks that is exacerbated with palpation and prolonged neck postures [17], neck pain with central and/or unilateral orientation within the area between the nuchal line superiorly and the spine of scapula inferiorly, limitation in neck motion that consistently reproduces symptoms, individuals aged 18 to 40-year-old, subjects with neck pain of ≥ 6 on Numeric Pain Rating Scale (NPRS) [17], individuals willing to participate in the entire duration of the study; i.e., four weeks were included in the study.

Exclusion criteria: Individuals with history of head or cervical injury, whiplash, a positive Spurling's test [4], distraction test [4], Valsalva maneuver [4], ULTT examination [4], individuals experiencing various headache types (alcoholism and other drug abuse) or with autonomic involvement, dizziness or visual disturbance or coordination deficits, Pittsburgh Sleep Quality Index (PSQI) score of less than 5 [18], Congenital conditions of cervical spine, inability to tolerate flexion rotation test [19], comorbidities such as malignancy or depression [20], Cognitive communication disorders limiting the ability to comprehend or converse were excluded from the study.

The randomisation was done with computer generated random numbers with 1:1 allocation in each group. The patients were blinded for the group allocation.

Study Procedure

Participants were screened for inclusion criteria and allocated into one of the two groups by simple randomisation (n=16 in each group). The anthropometric data and variables were assessed at baseline. Subjects in Group-1 were given intervention for neck pain in the form of Mulligan SNAG mobilisation along with cervical stabilisation exercises three times per week for four weeks. Subjects in Group-2 received only cervical stabilisation exercises three times per week for four weeks. The variables were assessed at the end of four weeks as shown in [Table/Fig-1].



[Table/Fig-1]: Flowchart of the study design (EMG: Electromyogram; PSQI: Pittsburg sleep quality index; NDI: Neck disability index, PPT: Pain pressure threshold).

Dependent variables:

Electromyographic (EMG) activity: The EMG is an electrodiagnostic procedure for evaluating and recording the electrical activity produced by skeletal muscles. The subject's skin was prepared in a standard fashion prior to electrode application to minimise electrical impedance. After cleaning and abrading the skin, bipolar surface electrodes (Ag/AgCl) were placed over the Upper Trapezius and Splenius Capitis consistent with established Surface Electromyography for the Non Invasive Assessment of Muscle (SENIAM) guidelines. The reference electrode for both the muscles was placed on the spinous process of C7 [21].

Maximal voluntary contractions (MVC) estimation: For the upper trapezius muscle, MVC was performed by resisted abduction of arm. For Splenius Capitis, ipsilateral cervical rotation was resisted. After demonstration of the required movement, the patient was asked to repeat the movement thrice with maximal effort against resistance for duration of approximately five seconds. A contraction was recorded for five second intervals, thrice. The average of the Root Mean Square (RMS) values was established as the MVC [21]. EMG was then recorded during the movement without any resistance and the average of three RMS values was estimated. EMG is expressed as the average RMS value during movement upon the average RMS value during MVC multiplied by 100- percentage of MVC force. EMG activity was recorded twice, once before and once after the intervention programme, at the end of week four.

Neck Disability Index (NDI): The disability that ensues as a result of neck pain was estimated using NDI. It is a self-reported questionnaire used to understand the impact of neck pain on the patient's daily life and to determine the level of disability as perceived by the patients during neck pain. The questionnaire has 10 items including personal care, lifting, reading, headaches, concentration, work status, driving, sleeping and recreation and each item has six response categories (range 0-5, total score range 0-50). The higher the score the more disability. The test-retest reliability of NDI was estimated as 0.50 [22]. NDI was administered twice, once before and once after the intervention programme, at the end of week four.

Numeric Pain Rating Scale (NPRS): NPRS is a self-report measure that has been used to measure changes in pain over time in patients with neck pain [23]. For scoring, a respondent selects a whole number (0-10 integers) that best reflects the pain intensity. The Intraclass Correlation Coefficient (ICC) value is reported to be at 0.76 in patients with mechanical neck pain [22]. NPRS was recorded twice, once before and once after the intervention programme, at the end of week four.

Pain Pressure Threshold (PPT): The PPT was measured with a pressure algometer applied at a constant rate of approximately 1 kg/cm^2/s until the subjects report a change of sensation from pressure to pain. PPT was tested over the upper trapezius muscle approximately 5 to 8 cm superomedial to the superior angle of the scapula [24]. Three measurements of pain threshold were recorded for each site and on each side of the body with an interval of approximately one minute between each measurement and the average value of the

three measurements noted. PPT was recorded twice, before and after the intervention programme, at the end of week four.

Pittsburgh Sleep Quality Index (PSQI): The PSQI is a reliable and valid tool with moderate evidence for structural validity. A score of more than 5 can be considered indicative of poor sleep quality [18]. PSQI was administered twice, once before and once after the intervention programme, at the end of week four.

Independent variables:

Mulligan Sustained Natural Apophyseal Glide (SNAG): Mulligan SNAG mobilisation to improve cervical ROM was as used by Bowler N et al., [12]. Treatment in the experimental group was administered 10 times in a row, 20 minutes total. The Mulligan SNAGs technique was applied to participants in the SNAGs group, with three 20-minute sessions per week, for a period of four weeks [16,25,26].

Conventional Rehabilitation: Conventional rehabilitation included exercise session comprising of 20-minute stabilisation exercises of neck muscles. The programme was carried out for three days/week for four weeks progressed weekly [15]. All exercise repetitions was increased progressively from 8 to 12. The exercises were divided as follows: cervical bracing exercises, isometric exercises and functional training. Cervical bracing exercises were carried out in neurodevelopment stages (supine, prone, quadrupedal and bipedal) for cervical spine using the stabiliser pressure biofeedback unit (Chattanooga, USA). The contraction was held for 10 seconds at each position with 10 repetitions. Then, cervical isometric exercises were performed directly forward, obliquely, toward right and left and directly backward by maintaining stabile spine with elastic resistive bands, with 10 repetitions with a holding time of 6-10 seconds each. Functional training with elastic resistance and exercise balls on unstable surfaces, with 10 repetitions with a hold of 10-15 seconds each. The participants began exercising with the latex yellow or red band. 10 repetitions with a holding time of 6-10 seconds each would be carried out. Upon performing 15 repetitions without significant pain or fatigue, progression to the next colour resistive band in the sequence of green and blue was done [15].

STATISTICAL ANALYSIS

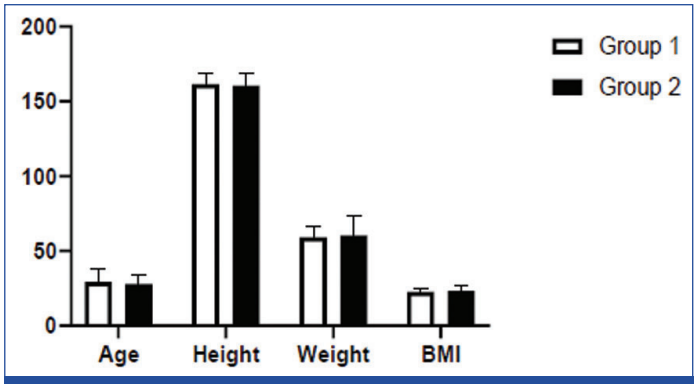
Statistical analysis was done using IBM Statistical Package for the Social Sciences (SPSS) Software version 24.0. Descriptive statistics is presented as mean±Standard Deviation (SD). Normality of the distribution is examined by Shapiro-Wilk test. Demographic and outcome variables have been examined at baseline between the groups using independent t-test and Mann-Whitney U test. To investigate the interaction between groups and time (Group × Time interaction), repeated measures Analysis of Variance (ANOVA) has been applied. Wilcoxon Signed-rank Test was used to establish the within group difference of NPRS. Level of significance was set at $p<0.05$.

RESULTS

At the baseline there was no significant difference for the demographic characteristics (age, height, weight and BMI) between the groups [Table/Fig-2,3]. To check for normality of the variables Shapiro-Wilk test was used. The homogeneity of the sample variables was established using independent student's t-test. At baseline, EMG activity of Upper Trapezius (right and left-side), EMG activity of Splenius Capitis (right and left-side), Global PSQI scores and pain pressure threshold (right and left-side) in both groups did not depict normal distribution and these values were then log transformed for further analysis.

Variables	Group-1 mean±SD n=16	Group-2 mean±SD n=16	t-value	p value
Age (years)	29.31±8.5	27.94±6.5	0.509	0.614
Height (cm)	161.63±6.9	160.39±8.2	0.460	0.649
Weight (kg)	59.31±7.1	60.38±12.7	0.290	0.774
BMI (kg/cm^2)	22.72±2.3	23.30±3.3	0.562	0.578

[Table/Fig-2]: Comparison of demographic data between groups at baseline. Group-1: Experimental group- Mulligan SNAG mobilisation with conventional exercises; Group-2: Control group- Conventional exercises; BMI: Body mass index.* Significant difference at <0.05.



[Table/ Fig-3]: Demographic data of subjects at baseline.

EMG activity of right Upper Trapezius: Repeated measures ANOVA depicted a significant effect for time, $F(1,30) = 4.803$, $p=0.036$, but non significant effect for group, $F(1,30) = 1.138$, $p=0.295$ and the group × time interaction, $F(1,30) = 0.088$, $p=0.769$ [Table/Fig-4].

EMG activity of left Upper Trapezius: Repeated measures ANOVA depicted a significant effect for time, $F(1,30) = 7.025$, $p=0.013$, but insignificant for group, $F(1,30)=0.348$, $p=0.560$ and the group × time interaction, $F(1,30)=0.460$, $p=0.50$ [Table/Fig-4].

EMG activity of right Splenius Capitis: For the EMG activity of Splenius Capitis, repeated measures ANOVA results depicted a significant effect of time on the EMG activity $F(1,30)=36.325$, $p=0.001$ and an insignificant effect for group, $F(1,30)=0.124$, $p=0.728$. The group × time interaction was statistically significant, $F(1,30) = 5.985$, $p = 0.021$[Table/Fig-4,5].

EMG activity of left Splenius Capitis: For the EMG activity of splenius capitis, repeated measures ANOVA results depicted a significant effect of time on the EMG activity at the $p<.05$ level for $F(1,30)=35.262$, $p=0.001$ and an insignificant effect for group, $F(1,30)=0.205$, $p=0.654$. The group×time interaction was statistically significant, $F(1,30)=6.849$, $p=0.014$ [Table/Fig-4,6].

Neck Disability: Neck disability was measured using Neck Disability Index (NDI). Results of repeated measures ANOVA indicated a significant effect with time, $F(1,30)=39.307$, $p=0.001$. The main effect of group was found to be insignificant, $F(1,30)=0.997$, $p=0.326$ and group × time interaction was statistically non significant, $F(1,30)=1.463$, $p=0.236$ [Table/Fig-7].

Subjective Sleep Quality: Sleep quality was measured using PSQI in terms of Global PSQI scores. Results of repeated measures ANOVA have shown a significant effect with time, $F(1,30) = 60.520$, $p=0.001$ but statistically insignificant with group, $F(1,30)=1.461$, $p=0.236$ and with group × time interaction, $F(1,30) = 0.017$, $p=0.898$ [Table/Fig-4].

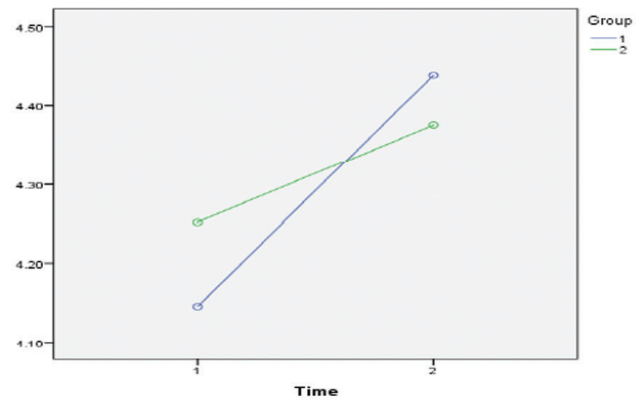
Right Pain Pressure Threshold: The results of repeated measures ANOVA have shown a significant effect with time, $F(1,30) = 55.071$, $p= 0.001$ and with group, $F(1,30) = 5.202$, $p= 0.030$ but statistically insignificant with group × time interaction, $F(1,30) = 3.148$, $p=0.086$ [Table/Fig-4].

Left Pain Pressure Threshold: The results of repeated measures ANOVA have shown a significant effect with time, $F(1,30) = 57.093$, $p= 0.001$ and with group, $F(1,30) = 6.727$, $p = 0.015$ but statistically insignificant with group × time interaction, $F(1,30) = 1.269$, $p=0.269$ [Table/Fig-4].

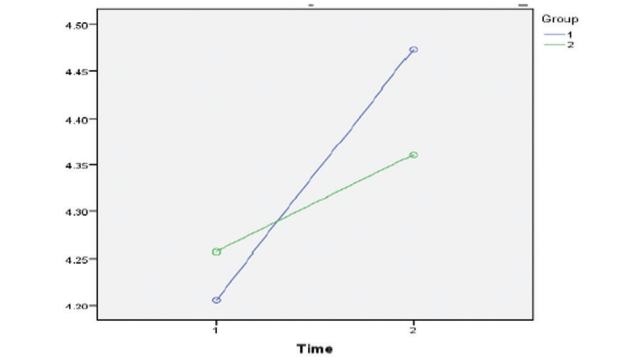
Pain: Pain was measured using NPRS. The results for pain by Mann-Whitney U test indicating between group differences were: Pre-NPRS=0.144 and Post-NPRS=0.939. Within group differences were measured by Wilcoxon Signed-rank test as Group-1, $p=0.001$ and Group-2, $p=0.002$ [Table/Fig-4].

Variables		Group-1 Mean±SD n=16	Group-2 Mean±SD n=16	Source	f-value	p-value	Partial eta squared (η2)
MVCRtUT (mv)	Pre	88.03 (10.4)	85.30 (16.6)	T	4.803	0.036*	0.138
	Post	93.27 (5.4)	88.71 (12.8)	G	1.138	0.295	0.037
				T×G	0.088	0.769	0.003
MVCLftUT (mv)	Pre	87.65 (8.9)	85.23 (12.0)	T	7.025	0.013*	0.190
	Post	90.75 (6.7)	90.22 (8.2)	G	0.348	0.560	0.011
				T×G	0.460	0.503	0.015
MVCRtSPL (mv)	Pre	65.64 (17.8)	71.62 (14.2)	T	36.325	0.001*	0.548
	Post	85.00 (7.8)	80.26 (11.2)	G	0.124	0.728	0.004
				T×G	5.985	0.021*	0.166
MVCLftSPL (mv)	Pre	68.62 (14.6)	72.87 (16.5)	T	35.262	0.001*	0.540
	Post	87.94 (7.5)	79.69 (13.8)	G	0.205	0.654	0.007
				T×G	6.849	0.014*	0.186
NDI (%)	Pre	40.08 (11.8)	34.63 (12.5)	T	39.307	0.001*	0.567
	Post	31.06 (11.7)	28.53 (11.01)	G	0.997	0.326	0.032
				T×G	1.463	0.236	0.046
GPSQI	Pre	10.75 (3.5)	9.44 (3.2)	T	60.520	0.001*	0.669
	Post	7.63 (2.1)	6.88 (2.7)	G	1.461	0.236	0.046
				T×G	0.017	0.898	0.001
RtPPT (kg/cm2)	Pre	8.19 (1.8)	7.65 (1.9)	T	55.071	0.001*	0.647
	Post	11.93 (2.1)	9.69 (2.4)	G	5.202	0.030*	0.148
				T×G	3.148	0.086	0.095
LftPPT (kg/cm2)	Pre	8.23 (2.1)	7.25 (1.5)	T	57.093	0.001*	0.656
	Post	11.93 (2.2)	9.69 (2.3)	G	6.727	0.015*	0.183
				T×G	1.269	0.269	0.041

[Table/Fig-4]: Summary of repeated measures ANOVA.
Abbreviations used- T: Time effect; G: Group effect; T×G: Time×Group Interaction; Group-1: Experimental Group- Mulligan SNAG mobilisation with conventional exercises; Group-2: Control Group- Conventional exercises; MVCRtUT: % Maximum Voluntary Contraction of Right Upper Trapezius; MVCLftUT: % Maximum Voluntary Contraction of Left Upper Trapezius; MVCRtSPL: % Maximum Voluntary Contraction of Right Splenius Capitis; MVCRtUT: % Maximum Voluntary Contraction of Left Splenius Capitis; NDI: Neck Disbility Index; GPSQI: Global Pittsburgh Sleep Quality Index; RtPPt: Right Pain Pressure Threshold; LftPPT: Left Pain Pressure Threshold; * Significant difference at p<0.05.



[Table/Fig-5]: Result of the group*time interaction effect of the right splenius capitis muscle from pre to post intervention in both the groups (Group-1: Experimental group (SNAG); Group-2: Control group).



[Table/ Fig-6]: Result of the group*time interaction effect on left splenius capitis muscle from pre to post intervention in both the groups. {Group-1: Experimental group (SNAG); Group-2: Control group}.

Group	Variables NPRS	Median (Interquartile range)
Group-1	Pre	7 (5-8)
	Post	5 (3-9)
Group-2	Pre	6 (3-8)
	Post	5 (2-8)

[Table/ Fig-7]: Median and interquartile range for Numeric Pain Rating Scale (NPRS).
Group-1: Experimental group- Mulligan SNAG mobilisation with conventional exercises; Group-2: Control group- conventional exercises; NPRS: Numeric pain rating scale.

DISCUSSION

The current study explored the variables of EMG activity, pain, disability, sleep quality in response to Mulligan SNAG mobilisations in neck pain patients. The results showed improved muscle activity over time in the upper trapezius and splenius capitis for both groups. However, a significant group*time interaction effect was noted only for splenius capitis, with Mulligan SNAG mobilisation showing greater percentage change, suggesting it as a better alternative to conventional rehabilitation. This aligns with studies reporting increased muscle activation following mobilisation due to accessory glide, which enhances spinal loading and extensor activity [27]. Baeske also highlighted the role of mobilisation in influencing articular and periarticular afferents impacting muscle activity [28]. Although the mechanisms remain unclear, Mehyar N et al., reported mobilisation effects on the Erector Spinae and lumbar multifidus, while Kim and Kim observed EMG changes in lumbar paraspinals post-Mulligan SNAG [29,30]. Ita et al., suggested mechanoreceptors and nociceptors within zygapophyseal joints play a role, as joint loading stimulates afferents transmitting nociceptive signals to the CNS [31]. Similarly, Shum M et al.,

demonstrated that mobilisation alters spinal stiffness, promoting muscle relaxation [32].

The study highlights EMG activity's role in neck extensor muscles and neck pain. While not statistically significant, Mulligan SNAG improvements provide preliminary evidence supporting muscle activity as a key treatment outcome. Both interventions similarly improved sleep quality, consistent with the bi-directional relationship between sleep and pain [33]. Pain relief, although not explicitly linked in the present study, aligns with another study who identified pain intensity and extent as predictors of poor sleep quality [34]. Current findings support existing evidence suggesting pain relief and functional improvements enhance sleep quality, possibly via improved ROM and reduced dysfunction. However, direct links between Mulligan mobilisation and sleep quality require further investigation.

Both groups showed improvements over time due to pain relief and increased ROM. Reduced cervical ROM in neck pain patients often involves coupled motion restrictions [35,36]. Guo et al., found upper cervical rotation deficits significantly impact overall neck motion [37]. Mulligan mobilisation reportedly improves ROM, pain and function [37]. Bishop et al., summarised that manual therapy reduces inflammatory markers, enhances muscle function and alleviates pain [38].

Group-1 showed greater pain reduction (NPRS score) than Group-2, indicating Mulligan mobilisation's superiority. Pain relief likely stems from manual therapy's modulatory effects [39,40]. Courtney et al., demonstrated improved pain modulation post-knee mobilisation in osteoarthritis [41], while Sterling M et al., reported increased pain pressure thresholds following mobilisation [14]. Buyukturan et al., noted Mulligan mobilisation's potential in addressing kinesiophobia and improving quality of life in older adults with neck pain [42]. Therefore, these findings support the alternative hypothesis under the assumptions of the study design.

Neck pain can be a debilitating condition, affecting the quality of life of patients. The results of the present research can be implemented into practice by the addition of Mulligan SNAG mobilisations to the conventional exercise programme to gain improvements in sleep quality and muscle activity, alongside the pain and disability improvements to enhance the performance of activities of daily living. Further evaluation of the variables as a long-term follow-up and using a 3-way ANOVA for analysing side, time and group effects can be done in the future. Elaborate studies could explore acute neck pain correlations with pain thresholds and sleep quality, as well as the role of Mulligan mobilisation in enhancing joint position sense and sleep outcomes.

Limitation(s)

The PSQI scores were analysed only globally; component score analysis can provide an insight into subjective sleep quality, or polysomnography can be used to understand the relationships between variables. Electromyography of only two muscles cannot conclusively point to problems in neck alone. Gender variations were unaddressed and the therapist was unblinded. Despite strict inclusion and exclusion criteria, several potential confounding factors may have influenced the outcomes. These include participants' occupational demands, psychological stress, variability in sleep quality above the PSQI threshold, use of concurrent medications and baseline levels of physical activity. While randomisation may reduce the effect of these confounders, they were not all measured and should be considered when interpreting the study's findings.

CONCLUSION(S)

The present study concludes that Mulligan SNAG mobilisation can be used as an adjunct to conventional exercise programmes to improve subjective sleep quality parameters, neck extensor muscle activity for stabilising the joints and pain pressure threshold over the trapezius muscle along with prior proved effects on pain and disability.

Acknowledgement

The authors would like to thank all the subjects for their cooperation and Jamia Millia Islamia University for all the facilities to perform the present study.

REFERENCES

[1] Hoy D, March L, Brooks P, Blyth F, Woolf A, Bain C, et al. The global burden of low back pain: Estimates from the Global Burden of Disease 2010 study. Ann Rheum Dis. 2014;73(6):968-74. Doi: 10.1136/annrheumdis-2013-204428. (PubMed).

[2] Abajobir AA, Abate KH, Abbafati C, Abbas KM, Abd-Allah F, Abdulle AM, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: A systematic analysis for the Global Burden of Disease Study 2016. Lancet. 2017;390(10100):1211-59. Doi: 10.1016/S0140-6736(17)32154-2.

[3] Côté P, van der Velde G, Cassidy JD, Carroll LJ, Hogg-Johnson S, Holm LW, et al. The burden and determinants of neck pain in workers: Results of the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders. Eur Spine J. 2008;17(Suppl 1):60-74. Doi: 10.1007/s00586-008-0626-4.

[4] Blanpied PR, Gross AR, Elliott JM, Devaney LL, Clewley D, Walton DM, et al. Neck pain: Revision 2017: Clinical practice guidelines linked to the International Classification of Functioning, Disability and Health from the Orthopaedic Section of the American Physical Therapy Association. J Orthop Sports Phys Ther. 2017;47(7)-A83. Doi: 10.2519/jospt.2017.0302.

[5] Bogduk N. The anatomy and pathophysiology of neck pain. Phys Med Rehabil Clin N Am. 2003;14(3):455-72. Doi: 10.1016/S1047-9651(03)00041-X.

[6] Walton D, MacDermid J, Nielson W, Teasell R, Chiasson M, Brown L. Reliability, standard error, and minimum detectable change of clinical pressure pain threshold testing in people with and without acute neck pain. J Orthop Sports Phys Ther. 2011;41(9):644-50. Doi: 10.2519/jospt.2011.3666.

[7] Finan PH, Goodin BR, Smith MT. The association of sleep and pain: An update and a path forward. J Pain. 2013;14(12):1539-52. Doi: 10.1016/j.jpain.2013.08.007. (PubMed).

[8] Sivertsen B, Lallukka T, Petrie KJ, Steingrímsdóttir ÓA, Stubhaug A, Nielsen CS. Sleep and pain sensitivity in adults. Pain. 2015;156(8):1433-39. Doi: 10.1097/j.pain.0000000000000131.

[9] Guzman J, Hurwitz EL, Carroll LJ, Haldeman S, Côté P, Carragee EJ, et al. A new conceptual model of neck pain: Linking onset, course, and care: The Bone and Joint Decade 2000–2010 Task Force on neck pain and its associated disorders. J Manipulative Physiol Ther. 2009;32(2 Suppl):28. Doi: 10.1016/j.jmpt.2008.11.007.

[10] Borghouts JA, Koes BW, Bouter LM. The clinical course and prognostic factors of non-specific neck pain: A systematic review. Pain. 1998;77(1):1-13. Doi: 10.1016/S0304-3959(98)00058-X.

[11] Salom-Moreno J, Ortega-Santiago R, Cleland JA, Palacios-Ceña M, Truyols-Domínguez S, Fernández-de-las-Peñas C. Immediate changes in neck pain intensity and widespread pressure pain sensitivity in patients with bilateral chronic mechanical neck pain: A randomized controlled trial of thoracic thrust manipulation vs non–thrust mobilization. J Manipulative Physiol Ther. 2014;37(5):312-19. Doi: 10.1016/j.jmpt.2014.04.003.

[12] Bowler N, Browning P, Lascurain-Aguirrebeña I. The effects of cervical sustained natural apophyseal glides on neck range of movement and sympathetic nervous system activity. Int J Osteopath Med. 2017;25:15-20. Doi: 10.1016/j.ijosm.2017.03.001.

[13] Said SM, Ali OI, Elazm SNA, Abdelraoof NA. Mulligan self-mobilization versus Mulligan SNAGs on cervical position sense. Int J Physiother. 2017;4(2):93-100. Doi: 10.15621/ijphy/2017/v4i2/141947.

[14] Sterling M, Jull G, Wright A. Cervical mobilisation: Concurrent effects on pain, sympathetic nervous system activity and motor activity. Man Ther. 2001;6(2):72-81. Doi: 10.1054/math.2000.0382.

[15] Celenay ST, Akbayrak T, Kaya DO. A comparison of the effects of stabilization exercises plus manual therapy to those of stabilization exercises alone in patients with nonspecific mechanical neck pain: A randomized clinical trial. J Orthop Sports Phys Ther. 2016;46(2):44-55. Doi: 10.2519/jospt.2016.5979.

[16] Shin EJ, Lee BH. The effect of sustained natural apophyseal glides on headache, duration and cervical function in women with cervicogenic headache. J Exerc Rehabil. 2014;10(2):131-35. Doi: 10.12965/jer.140098.(PMC)

[17] Nyirö L, Peterson CK, Humphreys BK. Exploring the definition of "acute" neck pain: A prospective cohort observational study comparing the outcomes of chiropractic patients with 0-2 weeks, 2-4 weeks and 4-12 weeks of symptoms. Chiropr Man Therap. 2017;25:24. Doi: 10.1186/s12998-017-0154-y.

[18] Moffett JK, McLean SM, Woodward C, Richards SH. A randomised controlled trial comparing exercise classes versus individual physiotherapy for patients with chronic low back pain. Physiotherapy. 2006;92(2):128-39. Doi: 10.1016/j.physio.2005.11.002.

[19] Hall T, Hardt S, Schäfer A, Wallin L, Lindblad M, Barbero M, et al. Mulligan Concept mobilizations with movement: A systematic review. J Man Manip Ther. 2019;27(2):63-74. Doi: 10.1080/10669817.2018.1479733.

[20] Aguila ME, Rebbeck T, Leaver A, Refshauge K, Hübscher M, Moloney N. Adding an internet-based intervention to usual care for chronic neck pain: A randomized controlled trial. Spine (Phila Pa 1976). 2017;42(17):1295-302. Doi: 10.1097/BRS.0000000000002020.
[21] Almosnino S, Pelland L, Pedlow SV, Stevenson JM. Between-day reliability of electromechanical delay of selected neck muscles during performance of maximal isometric voluntary contractions. J Electromyogr Kinesiol. 2010;20(6):1104-12. Doi: 10.1016/j.jelekin.2010.07.010.
[22] Gross AR, Hoving JL, Haines TA, Goldsmith CH, Kay T, Aker P, et al. Manipulation and mobilization for mechanical neck disorders: A systematic review. Spine (Phila Pa 1976). 2004;29(12):1541-48. Doi: 10.1097/01.BRS.0000128754.62794.95.
[23] Fernández-de-las-Peñas C, Cuadrado ML, Pareja JA. Myofascial trigger points, neck mobility, and forward head posture in unilateral migraine. Cephalalgia. 2006;26(9):1061-70. Doi: 10.1111/j.1468-2982.2006.01162.x. Ylinen J. Pressure algometry. Aust J Physiother. 2007;53(3):207.
[24] Ylinen J. Pressure algometry. Aust J Physiother. 2007;53(3):207. Doi: 10.1016/s0004-9514(07)70032-6.
[25] Childs JD, Cleland JA, Elliott JM, Teyhen DS, Wainner RS, Whitman JM, et al. Neck pain: Clinical practice guidelines linked to the International Classification of Functioning, Disability, and Health from the Orthopaedic Section of the American Physical Therapy Association. J Orthop Sports Phys Ther. 2008;38(9):A34. Doi: 10.2519/jospt.2008.0303.
[26] Hing W, Bigelow G, Bremner B, Wirick K. The effectiveness of Mulligan Concept (mobilisations with movement) manual therapy treatment for lateral ankle sprains: A systematic review. J Man Manip Ther. 2008;16(2):110-16. Doi: 10.1179/106698108790818527.
[27] Hurwitz EL, Carragee EJ, van der Velde G, Carroll LJ, Nordin M, Guzman J, et al. Treatment of neck pain: Noninvasive interventions. Eur Spine J. 2008;17(Suppl 1):123-52. Doi: 10.1007/s00586-008-0591-7.
[28] Rebbeck T, Sindhusake D, Cameron ID, Feyer A, Walsh J, La MM. A prospective cohort study of health outcomes following whiplash associated disorders in an Australian population. Inj Prev. 2006;12(3):93-98. Doi: 10.1136/ip.2005.010322.
[29] Kay TM, Gross A, Goldsmith C, Santaguida PL, Hoving J, Bronfort G, et al. Exercises for mechanical neck disorders: A Cochrane review update. Spine (Phila Pa 1976). 2005;30(20):53. Doi: 10.1097/01.brs.0000183180.15220.5b.
[30] Mulligan BR. Manual Therapy: NAGS, SNAGS, MWMs, etc. 5th ed. Wellington: Plane View Services Ltd; 2010.
[31] Cleland JA, Childs JD, Fritz JM, Cleland JA, Childs JD, Fritz JM, Whitman JM. Interrater reliability of the history and physical examination in patients with mechanical neck pain. Arch Phys Med Rehabil. 2006;87(10):1388-95. Doi: 10.1016/j.apmr.2006.06.011.
[32] Smidt N, van der Windt DA, Assendelft WJ, Deville WL, Korthals-de Bos IB, Bouter LM. The effectiveness of a conservative treatment program for patients with a non-specific neck or back pain. Spine (Phila Pa 1976). 2005;30(6)L63. Doi: 10.1097/01.brs.0000155401.90463.0f.
[33] Adams MA, Bogduk N, Burton K, Dolan P. The biomechanics of back pain. 2nd ed. Edinburgh: Churchill Livingstone; 2006.
[34] Leaver AM, Refshauge KM, Maher CG, McAuley JH. Conservative interventions provide short-term relief for non-specific neck pain: A systematic review. J Physiother. 2009;55(2):73-78. Doi: 10.1016/S1836-9553(09)70021-3.
[35] Leaver AM, Refshauge KM, Maher CG, McAuley JH. Conservative interventions provide short-term relief for non-specific neck pain: A systematic review. J Physiother. 2009;55(2):73-78. Doi: 10.1016/S1836-9553(09)70021-3.
[36] Bogduk N, McGuirk B. Management of acute and chronic neck pain: An evidence-based approach. 1st ed. London: Elsevier; 2006.
[37] Guzman J, Haldeman S, Carroll LJ, Nordin M, Carragee EJ, Peloso P, et al. Clinical practice implications of the Bone and Joint Decade 2000-2010 Task force on neck pain and its associated disorders. Spine (Phila Pa 1976). 2008;33(4 Suppl):213. Doi: 10.1097/BRS.0b013e3181644641.
[38] Hurwitz EL, Carragee EJ, van der Velde G, et al. Treatment of neck pain: Noninvasive interventions. Spine. 2008;33(4 Suppl):S123-S152.
[39] Dunning J, Butts R, Mourad F, Young I. Thoracic spine thrust manipulation combined with dry needling and kinesiology taping in the management of chronic mechanical neck pain: A randomized controlled trial. J Orthop Sports Phys Ther. 2017;47(7):488-500. Doi: 10.2519/jospt.2017.7096.
[40] Reid SA, Callister R, Milner AD, Poulos RG, Snodgrass SJ. Randomized trial of exercise effects on sleep quality and pain in adults with chronic musculoskeletal pain. Clin J Pain. 2016;32(10):875-83. Doi: 10.1097/AJP.0000000000000336.
[41] Sterling M. Neck pain and associated disorders: An evidence-based approach. 2nd ed. Edinburgh: Churchill Livingstone; 2011.
[42] Bialosky JE, Bishop MD, Price DD, Robinson ME, George SZ. The mechanisms of manual therapy in the treatment of musculoskeletal pain: A comprehensive model. Man Ther. 2009;14(5):531-38.

PARTICULARS OF CONTRIBUTORS:
1. Lecturer, Department of Physiotherapy, Maldives National University, Maldives.
2. Physiotherapist, Centre for Physiotherapy and Rehabilitation Sciences, Jamia Millia Islamia, New Delhi, India.
3. Assistant Professor, Department of Physiotherapy, GD Goenka University, Gurugram, Haryana, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Ashi Saif,
Assistant Professor, Department of Physiotherapy, School of Heathcare and Allied Sciences, GD Goenka University, Gurugram-122103, Haryana, India.
E-mail: saifashi21@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Feb 05, 2025
- Manual Googling: Sep 05, 2025
- iThenticate Software: Sep 08, 2025 (1%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Feb 04, 2025**
Date of Peer Review: **May 01, 2025**
Date of Acceptance: **Sep 11, 2025**
Date of Publishing: **May 01, 2026**