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Objective evaluation of Surface Electromyography Activity in Erector Spinae Muscle in Chronic Non-Specific Low Back Pain Following Mulligan concept of Lumbar Sustained Natural Apophyseal Glides.

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ABSTRACT

Non-Specific Low Back Pain (NSLBP) is often accompanied with movement limitations and can have produced some impact in wellbeing of life. It has garnered global attention due to its socioeconomic impact on communities. According to existing literature, there is no single superior treatment available for LBP. Treating LBP challenging due to the wide array of applications and treatment protocols. However, manual therapy has shown moderate to high evidence in effectively treating chronic LBP.

Mulligan SNAGs involve the therapist applied accessory passive glide to lumbar vertebrae concurrently active movement performed patient.

The aim of the study to assess the mode of action and potential for future applications in the therapy of CNSLBP.

Surface electromyography (SEMG) involves the recording of the electrical stimulus in the muscles of their motor units. It is used as one of the outcome measurement tools to detect and record electrical potentials from muscle fibres.

Objective:To investigate the impact of the Mulligan SNAGs on individuals with CNSLBP and overall effects in pain, ROM and EMG analysis.

Materials And Methodology:Forty subjects diagnosed with CNSLBP were selected, and informed consent was obtained. They splitted Group A experimental and Group B Control. Experimental group A received SNAGs, while control group B received Conventional Exercises. Each group about nine sessions in 3 weeks duration. The subjects evaluated using the Numerical Pain Rating Scale (NPRS), Modified Schober Test (MST) for range of motion, and Surface Electromyography (SEMG) on erector spinae muscles. Pre and post maximum voluntary contractions were measured.

Results:The experimental group showed significantly greater improvement in NPRS, lumbar flexion and extension compared than Group B Control, along with P value 0.001 (<0.05). EMG activity of the right and left erector spinae demonstrated significantly higher improvements in the Group A experimental compare than Group B control.

Conclusion:Mulligan SNAGs were more effectively improve ROM and reduce pain compare than conventional therapy among CNSLBP subjects.

Keywords: CNSLBP, SNAGs, SEMG, Conventional exercises.

INTRODUCTION

LBP generally affects 60-80% during a person's lifetime.[1,2,3] Among these cases, the majority (90%) are NSLBP. Other specific types of LBP account for 10% of cases, with many causative factors involved, such as position, abnormal movements and poor working environments affect spine.

NSLBP is generally defined as stiffness, muscle spasm and pain below the costal arch and above the horizontal gluteal crease.[4] Periodically last longer than three months are said to be CNSLBP, go along with limitations of ROM, persistent disablement and decreased well-being of life.[5] No specific therapy has been found to be superior in the treatment of LBP.[6]

The available treatments used have temporary effects.[7] Due to the availability of various manual therapy approaches, proper execution of manual therapy guidelines is essential to select appropriate treatments for effectiveness in CNSLBP. Therapeutic exercise enhances and reduces pain intensity and functional limitations.[8] Long-term disability can be improved through cognitive behaviour therapy,[9] which works well in the short term. However, the evidence seems to be low due to various reasons such as heterogeneity, making it impossible to reach a conclusion.

SNAGs are one of the techniques used in Mulligan Concepts and are performed in a weight-bearing position. SNAGs provide instant pain relief, increase ROM and correct positional faults of facet joints.[10] Mulligan proposed spinal techniques that facilitate restricted apophyseal joints and influence mobility in the intervertebral joint. Therefore, SNAGs techniques bring immediate changes in pain and spinal mobility.[11,12]

Most studies have focused on peripheral joints such as the shoulder,[13] elbow,[14] cervical region,[15] and sacroiliac joints.[16] However, few studies have concentrated on the effects of SNAGs in the lumbar region. Some evidence suggests that manual therapy techniques effectively reduce symptoms of LBP patients. However, essentially to develop an objective evaluation of outcomes in CNSLBP to facilitate widespread implementation. Therefore, these articles include SEMG analysis of the erector spinae muscle, pain measurement using the NPRS scale, and ROM recording using the MST test to determine the efficacy of SNAGs for treating CNSLBP.

Brandt recorded the erector spinae stimulus during box lifting.[17] James M. Wakeling et al. studied motor recruitment patterns during dynamic and locomotor tasks.[18] Assis Ro studied electrical lumbar multifidus muscles stimulus.[19] However, the present study only measures SEMG in erector spinae muscle.

METHODOLOGY:

STUDY SETTING:

Outpatient department,

PMR Division,

Rajah Muthaih Medical College and Hospital,

Annamalai University.

STUDY TYPE:

Interventional study (As per advice of our institutional ethical committee-

EC/NEW/INST/2020/1249)

SAMPLING:

Convenient Sampling

STUDY POPULATION:

40 subjects with CNSLBP

MATERIALS REQUIRED:

Couch

Chair

Pointer

Inch Tape

Towel

Mulligan Belt

NPRS Chart

SEMG Equipment

SELECTION CRITERIA:

INCLUSION CRITERIA:

Age group	:	20 to 45 years
Gender	:	Both Male and Female
Duration of pain	:	12 weeks and more

EXCLUSION CRITERIA:

Intervertebral Disc pathology

Lumbar degenerative disease

Lumbar Spondylolisthesis

Spinal fracture

Malignancy

Osteoporosis

Hip joint pathology

Lower limb fracture

Obesity

Pregnancy.

OUTCOME MEASURES:

NPRS

MST

SEMG

PROCEDURE:

Ethical approval was obtained from the IE committee at RMMCH. 40 subjects from the PMR OPD were recruited and screened for CNSLBP who met the selection criteria. The treatment procedure explained to them obtained inform consent from participants.

The subjects were randomly splitted into two main groups: Group A experimental (n=20) and Group B control (n=20).

Group A received Mulligan concepts SNAGs for 3 sets of 6 repetitions, 3 sessions per week over a three-week period. Group B received Conventional exercise protocols every day for 3 weeks.

Both groups underwent treatment duration of 3 weeks estimation using NPRS for pain, MST for ROM and SEMG for maximum voluntary contraction in the resting position of erector spinae-lumbar group before and after therapy.

NPRS:

The NPRS used to subjectively evaluate pain in both groups. The scale is useful tool to managing chronic LBA.[20] This scale has range starts from o up to 10. Where 0 exhibits without pain, 1 to 3 mild, 4 to 6 moderate, 7 to 9 severe and 10 worst. [21] The patient needs to circle the number that best represents their pain.

RANGE OF MOTION:

When it comes to lumbar range of movement, the Modified Schober test (MST) shows moderate validity but excellent reliability. During the test, the examiner stands behind the patient and marks the top of the venous dimples as the 1st line. The 2nd line is drawn 10 cm above the 1st line, and the 3rd line is 5 cm below the 1st line. The patient advised to bend frontwards without bending their knees.[22] The ROM is recorded by measuring the difference between the 15 cm recorded at the end of flexion. For extension, the patient advised hands on their buttocks for stabilization.[23]

SEMG:

Patients were clearly explained about the SEMG procedure and instructed to adopt a prone position with pillow support.[24] The measurement area was exposed. Precede to SEMG attachment, skin cleaned with 75% alcohol wipes,[25] impedance of skin was measured. The SEMG electrodes attached in the erector spinae muscle just 4cm away L1 spinous process with a distance of 2cm between electrodes. The reference electrode attached in styloid process of ulna.[26] SEMG measurements were recorded at resting position before and after intervention, with post-measurements taken on the same muscles. Details in figure (1).

APPLICATION OF INTERVENTIONS:

MULLIGAN CONCEPT OF SNAGs:

Patient advised to adopt high sitting position with both feet well supported, and the therapist is standing postero-lateral to the patient. The mobilization belt should be parallel to the floor and perpendicular to the patient ASIS and gluteal folds of therapists. It's important to place a towel between the belt and the patient's ASIS to prevent pressure. For central SNAGs, place the eminence hypothenar of one hand region were glides the involved lumbar segment spinous process. Another hand can rest on side of the plinth. In unilateral SNAGs, place the thumb of one hand under the facet joint of the involved segment, reinforced by the thumb of the other hand to push towards the eyeball of the patient. Apply a gentle, sustained anterior glide to the spinous process. While gliding, patient attempt the offending (flexion, extension, and side flexion). Encourage a breathing pattern to ensure comfort and relaxation. Ensure the glide is pain-free and apply end-range overpressure.[27,28] Treatment details in illustration in figures (2,3).

Group B (Control Group – Conventional Exercises):

1. Isometric gluteal muscles
2. Abdominals isometric
3. Isometric back extensors
4. Pelvic lifting
5. Cat – camel
6. Superman

DATA ANALYSIS AND RESULTS:

The study purposively assesses the effectiveness of mulligan SNAGs in CNSLBP, splitted as two groups, a group A experimental and group B control. The group A received treatment with Mulligan SNAGs, while the group B received treatment with Conventional therapy. The end point assesses through NPRS, lumbar spinal ROM evaluated by MST and SEMG activities of the erector spinae (ES) muscles.

Basic characteristics such as age, gender and BMI were comparison done inside the groups using the Mann-Whitney U test. Inside pre-post comparisons were analysis using either paired sample t-tests or Wilcoxon's matched pair test. Between-group analysis was evaluated using independent sample t-tests. The normality data analysis using Wilcoxon's signed rank test. The whole analysis of statistics was conducted using the Package for the SPSS-21.

Table – 1 Basic character of patient's study.

Variables	Experimental		Control		Total		Test statistics	
							z	p
Age in years (M,S.D)	35.30	7.14	35.75	6.98	35.52	6.97	0.14	0.892
Gender (N, %) Female Male	7 13	35 65	6 14	30 70	27 13	67.5 32.5	6.33	0.739
BMI (M, S.D)	22.21	2.37	23.03	2.13	22.62	2.25	1.19	0.242
Side (N, %) Right-Unilateral Left-Unilateral Center	3 3 14	15 15 70	-	-				

S.D-Standard deviation, M-Mean, N-Number, %-Percentage, z-Mann-Whitney U test, Probability-p.

It is inferred from Table:1 that the study mean of age patient shows 35.12±6.97 yrs and not shown significant different among age groups, z=0.14, p=0.892>0.05. The most of patient's statics were male, 67.5%, no difference was observed between groups, z=6.33, p=0.739>0.05. the mean BMI was 22.62±2.25 and no exist of difference of statistics between groups, z=1.19, p=0.242>0.05.

Table – 2 Comparison of pain score (NPRS) within group pre-post analysis

NPRS	Pre		Post		M.D		Test statistics	
	M	S.D	M	S.D	M	S.D	z	p
Experimental	5.32	0.70	2.12	0.48	3.23	0.66	3.70	0.001*
Control	5.17	0.78	3.22	0.65	1.94	0.54	3.89	0.001*

S.D-Standard deviation, M-Mean, Probability-p z, M.D- Mean difference, *-Significant.

It is inferred from Table 2 that NPRS was significantly improved from pre-mean of M=5.32±0.70 to post treatment mean of M=2.12±0.48 in the experimental group with the obtained z=3.70, p=0.001<0.05. The baseline NPRS in the control group was M=5.17±0.78 and it was improved significantly to 3.22±0.65 post therapy, z=3.89, p=0.001<0.05.

Table – 3 Differentiation lumbar flexion and extension ROM (MST) within group pre-post analysis.

MST (cm)	Pre		Post		M.D		Test statistics	
	M	S.D	M	S.D	M	S.D	z	P
FLEXION Experimental Control	3.89 4.59	0.84 0.66	6.75 6.09	0.45 0.64	2.85 1.80	0.59 0.28	3.89 3.74	0.001* 0.001*

EXTENSION Experimental Control	1.15 1.26	0.31 0.22	2.61 2.41	0.39 0.17	1.45 1.15	0.20 0.18	3.89 3.75	0.001* 0.001*

M-Mean, S.D-Standard deviation, z-Wilcoxon's signed rank test, M.D- Mean difference Probability- p, *-Significant.

Concluded in Table 3 that the improvement in lumbar flexion was significant in experimental group, baseline mean was M= 3.89±0.84 cm and post therapy mean was M=6.75±0.45 cm with the obtained mean improvement was M=2.85±0.59, z=3.89, p=0.001<0.05. in control, lumbar flexion was significantly improved with the mean difference of M. D=1.80±0.28 cm, z=3.74, p=0.001<0.05. With regard to lumbar extension, the group A shown improved statistically. pre mean=1.15±0.31 cm and post mean=2.61±0.39 cm with the pre-post difference M.D=1.45±0.20 cm, z=3.89, p=0.001<0.05. Control group showed significant improvement in lumbar extension with the obtained M.D=1.15±0.18 cm, z=3.75, p=0.001<0.05.

Table – 4 Erector spinae activity comparison in EMG – With in group pre-post comparison.

EMG	**Pre**		**Post**		**M.D**		**Test statistics**	
	M	**S.D**	**M**	**S.D**	**M**	**S.D**	**z**	**p**
ES - Right Experimental Control	96.43 95.13	2.71 3.19	236.36 171.39	13.34 5.37	139.93 76.25	13.34 4.28	3.62 3.72	0.001* 0.001*
ES – Left							t	p
Experimental Control	95.95 94.40	3.06 2.86	237.40 171.32	13.20 6.35	141.46 76.92	13.83 6.20	3.62 52.61	0.001* 0.001*

ES-Erector spinae, S.D-Standard deviation, M-Mean, t- paired sample t test, z-Wilcoxon's signed rank test, M.D- Mean difference, Probability- p, *-Significant.

Concluded in Table 4 erector spinae (Rt) activity was significantly improved in experimental group with the mean difference of M=139.93±13.34, z= 3.62, p=0.001<0.05. Control group also showed significant improvement in right erector spinae activity with the M.D=76.25±4.28, z=3.72, p=0.001<0.05. Left sided erector spinae activity shows that the group A shown improved statistical difference with obtained M.D=141.46±13.83, t=3.62, p=0.001<0.05. Control group had also demonstrated significant improvement in left erector spinae activity with the M.D=76.92, t=52.61, p=0.001<0.05.

Table – 5 Differentiation of study variables between groups.

Variables	**M.D**	**t**	**p**
NPRS	1.29	6.33	0.001*
MST Flexion Extension	1.05 0.31	6.81 4.78	0.001* 0.001*
ES Right Left	63.67 64.54	19.24 17.99	0.001* 0.001*

M.D-Mean difference, Probability- p, *-Significant, t- independent sample t test,.

Table 5 concluded there was meaning fully highest improvement on NPRS in the group A than in the group B with the obtained M.D=1.29, t=6.33, p=0.001<0.05. There was significantly highest upgrade in lumbar extension and flexion in the group A than in group B with the obtained M.D=1.05 cm, t=6.81, p=0.001<0.05 and M.D=0.31, t=4.78, p=0.001<0.05 respectively. EMG activity of right erector spinae demonstrated significantly higher improvements in experimental group than in controls with the obtained M.D=63.67, t=19.24, p=0.001<0.05. left sided erector spinae activity also demonstrated meaning fully improvement in

group A, M.D=64.54, t=17.99, p=0.001<0.05.

Fig: 1. EMG Analysis for Erector spinae muscle.

Fig: 2. Mulligan SNAGs in Flexion.

Fig: 3. Mulligan SNAGs in Extension.

RESULTS:

Average study age of the patients was 35.12±6.97 years and no difference in statistics inside groups, z=0.14, p=0.892>0.05.

There was meaningfully highest upgrade in NPRS in the group A than group B with the obtained M.D=1.29, t=6.33, p=0.001<0.05.

There was significantly higher upgrade in lumbar extension and flexion in the group A than group B with the obtained M.D=1.05 cm, t=6.81, p=0.001<0.05 and M.D=0.31, t=4.78, p=0.001<0.05 respectively.

EMG activity of right erector spinae demonstrated significantly higher improvements in experimental group than in controls with the obtained M.D=63.67, t=19.24, p=0.001<0.05. left sided erector spinae activity also demonstrated significantly higher improvements in the experimental group with the obtained M.D=64.54, t=17.99, p=0.001<0.05.

DISCUSSION:

The study explored Mulligan SNAGs mechanical effects in CNSLBP subjects. In this study, descriptive statistics showed the average Mean Age was 35.12±6.97 Mean BMI Value in 22.62±2.25. the gender distribution showed 62% of male subjects where as 30% belonged to female participants.

The study results suggest that upgrade in pain, lumbar ROM, some sort of voluntary increased in SNAGs group than conventional group.

The study results matched in previous recommendations.[29] The observed improvements due to the capsular strain correction of facet joints of lumbar region. As we know the role of facet joints of lumbar and its stabilized joint, proprioception, pain, SNAGs mobilization over the affected facet joints, releases the strain on capsule there by improve the mobility of the spinal joint.

There is significant improvement in Pain reduction in experimental group compare with control group with t value 6.33 and p value 0.001 <0.05.

The possible improvement due to the following explanation. Our pain reduction match others authors,[29] the response comprises multiple factors among which positional fault of facet joints, SNAGs application relives the positional fault, thereby enhance pain-free movement. Hing and Vicenzino narrated instant pain relief and SNAGs application non-opioid and pain inhibit happened.[30]

Further progressive mobilization desensitization of nervous system occurs among the habituation, also the pre-synaptic inhibition and noxious impulses, thereby pain was reduced.[31] There was also psychological effect of SNAGs associated with pain severity. SNAGs result in reduction in fear of avoidance. Therefore, functional improved achieved in activity level.[32]

There is meaningfully high improvement in lumbar extension and flexion in group A compare with group B with t value 4.78 and p value 0.001<0.05. The possible explanation as follows capsular strain correction, stability, pain, proprioception improved.[33]

The other mechanism suggest that SNAGs work on bring back the normal mechanics also improve mobility, muscular and flexibility as well. At the same time one study show minimal improvement in pain, notched that study has heterogenic in selection the same.

This study does not include the functional disability instead of that objective evaluation done through electromyographic measurement of maximum voluntary contraction of certain important muscle like lumbar erector spinae muscle. After the application of SNAG treatment, some sort of improvement reveals lumbar erector spinae muscle.

One of the studies SEMG not able to measure the isolate activity of lumbar multifidus, erector spinae during clinical test. Moreover, in the study SEMG measured over erector spinae. In future others muscle like Quadratus lumborum, iliopsoas, multifidus and tensor fascia latae EMG activities can be measured.

In our study conventional exercise group too shows improvement that is match with author Zachary Smrcina et al the reason might be strengthened core muscle helps in rehabilitate the CNSLBP subjects.[34]

Due to some reasons 8% of them are drop out. Among the various manual therapy approaches, Mulligan SNAGs could be recommended as one of the treatment adjuncts in CNSLBP subjects in future.

LIMITATION:

It includes only small numbers of subjects, in future study can be done with huge sample size with follow up.

The study can be applied over the lumbar specific patients along with advanced and more specific muscles can be recorded.

CONCLUSION:

The study provides evidence that Lumbar SNAGs better than conventional program in CNSLBP subjects.

SOURCES OF FUND AND CONFLICT OF INTEREST:

This study has not allotted any fund and no conflict of interest.

FUTURE RECOMMENDATIONS:

1. Lumbar SNAGs added to conventional therapy for CNSLBP.
2. The physiological effects of SNAGs application can be deeply studied in future studies with more selected objective evaluation in Pain and ROM.

REFERENCES:

1. Andersson GBJ. Epidemiology of low back pain. Acta Orthop Scand 1998: s281:28-31.
2. Waxman R, Tennant A, Helliwell P.A prospective follow-up study of low back pain in the community. Spine 2000; 25:2085-90.

3. COST B13 working Group on Guidelines for the management of Acute Low Back pain in Primary Care (2004) 8.
4. Maher C, underwood M, Buchbinder R, Non-specific low back pain. Lancet 2017; 389:736-747.
5. Wettstein M, Eich W, Bieber C, Tesarz J, Pain intensity, disability and quality of life in patients with chronic low back pain: does age matter? Pain Med 2019; 20:464-475.
6. Van Middelkoop M, Rubinstein SM, Verhagen AP, Ostelo R W, koes BW, van Tulder MW. exercise therapy for chronic non-low-back pain. Best Pract Res Clin Rheumatol 2010:24(2)193-204.
7. Wand BM, O'Connell NE. Chronic non -specific low back pain – sub- groups or a single mechanism? BMC Musculoskelet Disord. 2008;9(1):11.
8. Hayden JA, EllisJ, Ogilvic R, Malmivaara A, van tulder MW. Exercise therapy for chronic low back pain. Cochrane database syst rev 2021; 9:CD009790.
9. Henschke N, Ostelo RW, van Tulder MW, et al. Behavioural treatment for chronic low back pain. Cochrane Database syst Rev 2010; 7:CD002014.
10. Hisham Mohamed H, Neveen Abdellatif A-R, Omaima MK, Hassan HA: Effect of Mulligan concept Lumbar SNAGs on Chronic nonspecific low back pain. J chiropr Med 2017; 16:94-102.
11. Battie, MC · Cherkin, DC · Dunn, R. Managing low back pain: attitudes and treatment preferences of physical therapists. *Phys Ther.* 1994; 74:219-226.
12. Jette, AM · Smith, K · Haley, SM Physical therapy episodes of care for patients with low back pain. *Phys Ther.* 1994; 74:101-115.
13. Gokhan Doner, PT, MSc et al Evaluation of mulligan's technique for Adhesive Capsulitis of the shoulder Rehabil Med 2013; 45: 87-91.
14. Kevser Sevik Kacmaz PT, MSc et al. Immediate effects of Milligan Mobilization on Elbow Proprioception in Healthy individuals: A Randomized Placebo-controlled Single-Blind Study. Journal of manipulative and physiological therapeutics volume 46, issue1, January 2023, pages 59-64.
15. Anam Manzoor et al. comparison of effectiveness of muscle energy technique with mulligan mobilization in patients with non-specific neck pain.
16. Sabah Mohammed Easa Alkady et al. Efficacy of mulligan mobilization versus Muscle Energy technique in chronic sacroiliac joint dysfunction. Int j physiother. Vol4(5), 311-318, October (2017) ISSN: 2348-8336.
17. Brandt et al. inter-day reliability of surface electromyography recordings of the lumbar part of erector spinae longissimus and trapezius descendens during box lifting. BMC Musculoskeletal Disorders 2017, 18:519. DOI 10.1186/s 12891-017-1872-y.
18. James M. Wakeling, patterns of motor recruitment cn be determined using surface EMG. Journal of electromyography and kinesiology 19 (2009) 199-207. Doi: 10.1016/j.jelekin.2007.09.006.
19. Assis RO et al, study on placing electromyography electrodes on lumbar multifidus muscles. J.Morphol.sci, 2011, vol 28, no. 1, p.46-51.
20. John D. Childs, PT, PhD, MBA, et al. Responsiveness of the Numerical Pain Rating Scale in Patients with Low Back Pain. SPINE volume 30, Number 11, pp 1331-1334, 2005.
21. johnas Verbrugghe et al, High Intensity Training to treat Chronic Nonspecific Low Back Pain: Effectiveness of Various Exercise Modes. J.Clin. Med. 2020, 9,2401; doi:10.3390/jcm9082401.

22. cheng Gong MS, et al. comparison of Feg spinal mobilization with Maitland mobilization in management of Chronic nonspecific low back pain: A cohort study Medicine (Baltimore), 2023 feb 17; 102(7): e 32984. Doi: 10.1097/MD.0000000000032984.
23. Dr. akta dabgar et al. effect of Bowen Technique on pain, ROM, and function in subjects with Non-specific Low Back Pain- A Pilot study. IJARP. Volume5 issue 5, may 2022.
24. AbdoudJ, Nougarou F, Page I et al. Trunk motor variability in patients with non -specific chronic low back pain. Eur J Appl physiol.2014; 114:2645-54.
25. Jie Qiao, MM, Shu-LI Zhang MM et al. A study on the paraspinal muscle surface electromyography in acute nonspecific lower back pain. Medicine (2019) 98:34(e 16904) Doi. Org/10.1097/MD. 0000000000016904.
26. Roger Gomes Tavares Mello et al. Lumbar multifidus and erector spinae electromyograms during back bride exercise in time and frequency domains. Journal of Back and Musculoskeletal Rehabilitation 29(2016)123-133. DOI: 10.3233/BMR-150607.
27. Mulligan B. Manual therapy: NAGS, SNAGS, MWMs; 4th edition; 2004.
28. Dr. Deepak Kumar, Manual of Mulligan concept; reb 2015.
29. Hidalgo b, pittance L, et al. Short-term effects of mulligan mobilization with movement on pain, disability and kinematic spinal movements in patients with nonspecific low back pain: a randomized placebo-controlled trial. J Manipulative Physiol Ther 2015;38 (6):365-374.
30. Vicenzino, B.; Hing, W.; Hall, T.; Rivett, D. Mobilisation with Movement: The Art and the science, 1st ed.; Elsevier: Melbourne, Australia, 2011.
31. Schmid, S; Wilson, D.A.; Rankin, C.H. Habituation mechanisms and their importance for cognitive function. Frint. Integr. Neurosci.2014, 8, 97. PubMed.
32. Jackson, T; wang, Y.; y.; Fan, H. self-efficacy and chronic pain outcomes: A Meta-analytic review. J. Pain 2014, 15, 800-814. (PubMed).
33. Gong, w. The influence of lumbar joint mobilization on joint position sense in normal adults. J. phys.ther. sci.2014, 26, 1985-1987.
34. Zachary Smrcina, Sarah Woelfel and Christopher Burcal et al, A Systematic Review of the Effectiveness of Core Stability Exercises in Patients with Non-Specific Low Back Pain. Int J Sports Phys Ther. 2022; 17(5): 766–774. Doi: 10.26603/001c.37251