Effects of Thoracic Extension versus Thoracic Stabilization Exercises on Pain, Stiffness, Range ofMotion, Disability and Posture in patients with Maigne's Thoracic Pain

Running Head: Extension Vs Stabilization exercises in thoracic pain

Rubab Nadeem[1], Syed Shakil Ur Rehman[2], Dr khizra Hamid[3], Moeen Ahmad Khan[4], Virsha Riaz[5], Saddiqa Qamar[6]

DPT, MS-PT & Lecturer University Of Management and Technology[1], Dean at Riphah International University Faculty of Rehabilitation and Allied Health Sciences[2], Lecturer at University of biological and applied sciences[3], DPT, MS-PT (OM) & Lecturer at University of Management and Technology[4], Lecturer at NUR International University Lahore[5], MS –MSK & Demonstrator at University of Management and Technology, School of Health Sciences Lahore[6]

ABSTRACT

Background: Maigne's syndrome particularly originates from mid-thoracic region and effects muscles of cervical and scapular plane, causes functional limitation, prohibits spine for rotation and bending without pain.

Objective: To determine the comparative effects of thoracic extension and thoracic stabilization exercises on range of motion, disability, pain, posture and stiffness in individuals with Maigne's Thoracic Pain.

Methodology: A randomized trial was carried out. Inclusion criteria were participants of age between 20-45 years, Numeric pain rating scale (NPRS) value ≥4, Cobb's Angle more than 40° and thoracic region pain at T4-T6. Based on the eligibility criteria, a total of 32 participants were categorized into two groups. First group received thoracic extension exercises while the second group received thoracic stabilization exercises. The baseline values of all variables including pain, stiffness, range of motion, disability and posture was recorded on day one, at the end of the three-week treatment session, using numeric pain rating scale, bubble inclinometer, Standing Thoracic X-ray, Kyphosis Index, and Thoracic Stiffness Index and Revised Oswestry Thoracic Pain Questionnaire.

Results: Mean age in group A was 26.93 ± 5.16 and in group B it was 28.60 ± 6.42. Mean BMI of group B participants was 21.25 ± 3.37 and group A had mean BMI of 23.62 ± 2.07. 33.3% participants in group. Across group analysis revealed a statistical significant disparity (p-value<0.05) was found on NPRS, Cobb's angle, thoracic extension, kyphotic index relax posture, kyphotic best relax posture, thoracic stiffness index and ROTPDQ in both groups (A and B) after intervention of 3 weeks.

Conclusion: Thoracic extension exercises were found to more effective than thoracic stabilization exercises in managing pain, stiffness and disability along with improving range of motion and posture in patients with Maigne's thoracic pain.

Keywords: Extension exercises, Hyperkyphosis, Kyphosis, Maigne's Thoracic Pain, Posture, Thoracic Stabilization Exercises.

INTRODUCTION

Upper thoracic pain that particularly originates from mid-thoracic region and effects muscles of scapular plane and cervical is termed as Maigne's syndrome.[1] In general population, prevalence of upper thoracic pain was recorded to be 15% that was considerably much lower than neck and lumbar pain. This syndrome causes functional limitation and prohibits spine for rotation and bending without pain.[2]

Most reported symptoms of Maigne syndrome are tenderness and stiffness of thoracic muscles chiefly inter-scapular muscle group at the level of T5-T6. The nature of pain is often unilateral that aggravates by overhead activities. Thoracic spine provides a base of support at cervico-thoracic junction to help cervical spine carry out its normal biomechanics. Discomfort in either thoracic or cervical results in mobility restriction affecting the associated character. However, thoracic impairment further leads to hyper-kyphosis because of dysfunction of scapula-thoracic muscles; serratus anterior, levator scapulae and trapezius. Any abnormality in upper thoracic causes loss of proper kinematics and alters the mechanical loading of cervical spine.[3]

Weariness of para-spinal muscles initiates abnormal curvature of thoracic spine. Hyper-kyphosis happens when kyphosis angle exceeds normal limit >40 degrees due to imbalances of muscles and improper posture.[4] Upper-thoracic pain starts a chain reaction of impairment; kyphosis is followed hyper-extension of upper cervical spine and hyper-flexion of lower cervical region.[5] Multiple ergonomic factors are prime factors for postural abnormality that leads to thoracic

uneasiness. Among age and degeneration, work related environment is main factor responsible for Maigne syndrome.[6]

Upper thoracic and cervical impairment adversely affects local trunk facilitation, reduced proprioceptive activity and distorted recruitment patterns of muscles. This structural and physiological malformation leads motor control dysfunction which put more compressive loads on spine. If untreated, maigne syndrome could result in repeated micro trauma and weakness of deep core muscles. Thoracic kyphosis is automatically associated with forward head posture and irregular scapular kinematics. Multimodal intervention consisting of neuro dynamics and stabilization protocol can help improve the worsening condition.[7]

Evidence based exercise therapy has proven to be effective intervention in treatment of upper thoracic pain. In general intervention protocol, prominence on proper biomechanics and work on scapular functions can reduce pain and disability. Multiple meta-analyses shows that upper body active movements, breathing techniques and head, cervical, shoulder alignment via various intervention programs can help improve impairment symptoms of maigne syndrome. Resistance exercises could be helpful in developing strength in weakened muscles and securing muscular endurance to maximum. Similarly, tightness of muscles could be considerably reduced with help of stretching and flexibility exercises.[8]

Thoracic dysfunction may accelerate degenerative process even before old age. Tearing of connective tissue due to excessive thoracic flexion can result in mass muscular spasm. The condition becomes so sensitive that patient will feel even during picking up a pencil from floor or transferring a shopping bag to another person. The sudden thoracic pain that passes through the structures becomes irritating and limits individual to perform complex movements. Exercises like serrates push, prone shoulder extension, straight arm extension can help restore normal function and range of motion of spine. Apart from this muscle energy techniques and massage can help restore normal tissue health.[9]

Thoracic extension exercises assist in improving vertebral loading, trunk control and balance. Prior studies have observed great efficacy by this intervention for upper thoracic pain. Some of the exercises involved in this program are neck retractions, scapular retraction exercises and shoulder shrugging. It is mostly instructed for 30 repetitions for 10 day straight.[10] Postural pain and instability, respiratory function and low quality of life due to this ailment can be diminished by application of thoracic stabilization exercises. Numerous other interventions like yoga, Pilates

and balance training program are also in action for improvement of thoracic disability. With standard time and accuracy of intervention, patients shows positive effects within the duration period of physiotherapy sessions.[11]

Maigne's thoracic pain has been a under discussed area of disorders despite of it being a common disorder among adults. Very limited treatment strategies were available for its management. This study aimed to provide evidence which may improve treatment strategies for management of Maigne's Thoracic pain countering hypo mobility and movement restriction at thoracic region, focusing on muscular and postural componentand also provide researchers and clinicians path to explore further preventive measures, lifestyle modifications and treatment strategies to cater this problem.

MATERIALS AND METHODS

Study design and population

The study was a randomized clinical trial registered in the NIH Clinical Trial Library in the United States and has a reference number NCT05395078. The investigation was conducted at the University Medical Centre in Lahore. The study period was ten months. By using Open Epitool, a total sample size of 28 was calculated, based on baseline values for the variable disability.[12] A 15% attrition rate was added which makes the sample size a total of 32 (Table 1). Non- probability convenient sampling technique was used.

Table 1: Sample size calculation

Mean1	12.8
Mean2	10.4
Variance	5
Confidence level	0.95
Power	0.8
Tails	2
Calculated sample size	**28**
After 15% attrition rate	**32**

Selection Criteria

Selection criteria included participants of age 20 to 45 years [13] , Numeric pain rating scale (NPRS) value ≥4 [13], Cobb's Angle more than 40°[13] and Thoracic region pain at T4-T6.[3]

Exclusion criteria were patients having any structural abnormalities like fractures/spondylosis, having history of any neurological or musculoskeletal problems[12] and having history of cervical or thoracic surgery or psychological disorders.[12]

Intervention Protocol

Volunteers were approached to participate in the study's screening procedure via an advertising at the University Medical Centre, Lahore. Before obtaining their written consent, all patients were provided with information about the purpose and study procedures.

Subjects were cetegorized into two groups each with 16 persons through random allocation. In group A, patients received Thoracic Extension Exercises with conventional physical therapy (hot pack, manual therapy and exercise therapy). In group B patients received Thoracic Stabilization Exercises with conventional physical therapy (hot pack, manual therapy and exercise therapy).

Group A: Thoracic Extension Exercises (2× 10 reps each/day). This workout programme emphasised thoracic spine extension and trunk muscular flexibility. A specialised protocol of thoracic extension in sitting, prone, quadruped position, on foamy roller, angled wall stretch, corner stretch + heat pack (ten min) + Trapezius and Levator Scapulae stretching + Myofascial Release + Thoracic spinal mobilisation (three sets of three repetitions each/day).[14] For three weeks, a 45-minute session was held three times each week on alternate days.

Group B: Thoracic stabilisation exercises (two x ten repetitions each/ day). This workout programme focused on thoracic musculature, static and dynamic posture. A specialised protocol of draw-in and chin tucks in crook lying, prone, sitting, and standing, chin-tuck prone elevation exercises with arm on sides, arms behind head, or overhead, a heat pack (ten minutes), trapezius and levator scapulae stretching, myofascial release, and thoracic spinal mobilisation (three sets of three repetitions each). [14] For three weeks, a 45-minute session was held three times each week on alternate days.

The baseline values of all the dependent variable was recorded on day one, at the end of the three- week treatment session, using numeric pain rating scale, bubble inclinometer, Standing Thoracic X-ray, Kyphosis Index, and Thoracic Stiffness Index and Revised Oswestry Thoracic Pain Questionnaire.

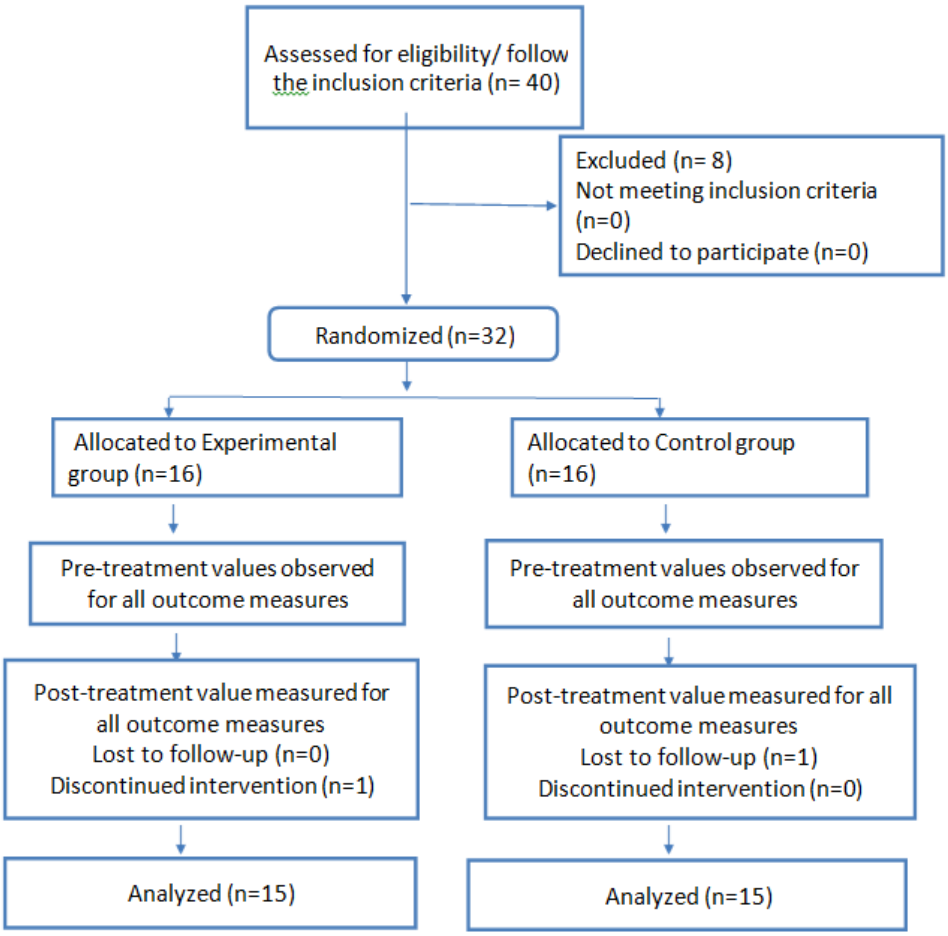
Pain was measured by NPRS (Numeric pain rating scale), which is a numeric scale in which a respondent chooses a number from 0–10 which represents the intensity of his pain. [14] Bubble inclinometer was used to measure the thoracic extension range of motion. Inclinometer was

placed near joint to be measured; dial was turned until scale reads 0; joint was taken through its range; range traveled directly from dial was read.[11] Cobb's angle was measured by standing thoracic X-ray. The radiography lab took a lateral view X-ray of each subject's thoracic spine. The subjects stood in a comfortable stance with their arms lifted in front of them for the X-ray. [2] The kyphosis index was calculated using the Flexi curve ruler, a flexible plastic 60-cm ruler used to determine the contour of the thoracic curve. KI was computed by multiplying 100 by the ratio of thoracic width to thoracic length, or KI = (thoracic width/length)×100.[4] The Thoracic Stiffness Index (TSI) was obtained by dividing the value of the KI in relaxed posture by the value of the KI in best posture.[4] The Revised Oswestry Thoracic Pain Disability Questionnaire (ROTPDQ) was utilized to assess disability resulting from thoracic pain. The self-reported disability questionnaire assesses both pain as well as functional status.[15] Figure 1 shows the consort slow diagram.

Statistical Analysis

SPSS version 25 was utilised for the analysis of data. Using the Shapiro-Wilk test, the normal distribution of outcome measures was assessed. To provide a summary of group measures taken over time, frequency tables, pie charts, bar charts, and histograms were used. The Mann Whitney-U test and the Independent T test were employed to quantify changes between groups. Changes within groups were analyzed by Paired T test and Wilcoxon Test was used.

Figure 1: Consort Flow chart



RESULTS

Table 2 demonstrates the demographic statistics of the trial. Mean age in group A was 26.93 ± 5.16 and in group B it was 28.60 ± 6.42. Mean BMI of group B participants was 21.25 ± 3.37 and group A had mean BMI of 23.62 ± 2.07. 33.3% participants in group A were males and 66.7 were females. 53.3% patients in group B were females and 46.7% were males.

Table 2: Demographic data

Study Groups		N		Mean ± SD
Group A	(Thoracic Extension Exercises)	16	Age	26.93 ± 5.16
			BMI	23.62 ± 2.07
Group B	(Thoracic Stabilization Exercises)	16	Age	28.60 ± 6.42
			BMI	21.25 ± 3.37

BMI: Body Mass Index

Table 3 displays the across Group Comparison of group A and B on NPRS, Cobb's angle, thoracic extension, kyphotic index relax posture, kyphotic best relax posture and ROTPDQ. A statistical significant disparity (p-value<0.05) was found in both groups (A and B) after intervention of 3 weeks.

Table 3: Across Group Comparison (Independent Sample T Test)

	N	Study Groups	Mean ± SD	P Value
NPRS (Baseline)	16	Group A	6.85 ± 1.45	.492
		Group B	7.20 ± 1.14	
NPRS (Post 3 weeks)	15	Group A	1.73 ± 0.70	.000
		Group B	5.20 ± 2.54	
Cobb's Angle (Baseline)	16	Group A	47.73±1.48	.796
		Group B	47.20±1.29	
Cobb's Angle (Post 3 weeks)	15	Group A	45.50±2.16	.042
		Group B	46.86±1.55	
Thoracic Extension (Baseline)	16	Group A	19.00±2.44	.409
		Group B	19.73±2.34	
Thoracic Extension (Post 3 weeks)	15	Group A	22.66±1.63	.002
		Group B	20.46±1.95	
Kyphotic Index relax posture (Baseline)	16	Group A	14.68 ± 0.45	.096
		Group B	15.04 ± 0.66	
Kyphotic Index relax posture (Post 3 weeks)	15	Group A	13.63 ± 0.25	.000
		Group B	14.63± 0.67	
Kyphotic best relax posture (Baseline)	16	Group A	13.70 ± 0.43	.000
		Group B	14.60 ± 0.75	
Kyphotic best relax posture (Post 3 weeks)	15	Group A	12.26 ± 0.28	.000
		Group B	14.25± 0.72	
ROTPDQ (Baseline)	16	Group A	38.53 ± 3.99	.195
		Group B	40.46 ± 3.97	
ROTPDQ (Post 3 weeks)	15	Group A	21.86 ± 3.46	.000
		Group B	33.20 ± 4.41	

NPRS: Numeric Pain Rating Scale, ROTPDQ: Revised Oswestry Thoracic Pain Disability Questionnaire

Table 4 displays the across Group Comparison of group A and B on thoracic stiffness index. A statistical significant disparity (p-value<0.05) was found in both groups (A and B) after intervention of 3 weeks.

Table 4: Across group comparison of thoracic stiffness index (Mann Whitney U test)

Study Groups		N	Mean Rank	Sum of Ranks	Z value	Sig. Value
Thoracic stiffness index (Baseline)	Group A	16	17.00	255.0	-1.795	0.073
	Group B	15	14.00	210.0		
Thoracic stiffness index (Post 3 weeks)	Group A	16	22.93	344.0	-4.895	0.000
	Group B	15	8.07	121.0		

Table number 5 displays the with-in Group comparison of pre and post intervention on NPRS, Cobb's angle, thoracic extension, kyphotic index relax posture, kyphotic best relax posture and ROTPDQ. A statistical significant disparity (p-value<0.05) was found in pre and post intervention value of both groups A after intervention of 3 weeks. But in group B no significant disparity (p-value>0.05) was found in pre and post intervention value of NPRS and Cobb's angle after intervention of 3 weeks.

Table 5: Within Group Comparison of variables (paired t test)

Study Groups		N	Mean ± SD	P Value
Group A	NPRS (Baseline)	16	6.85 ± 1.45	.000
	NPRS (Post 3 weeks)	15	1.73 ± 0.70	
Group B	NPRS (Baseline)	16	7.20 ± 1.14	.009
	NPRS (Post 3 weeks)	15	5.20 ± 2.54	
Group A	Cobb's Angle (Baseline)	16	47.73 ± 1.48	.001
	Cobb's Angle (Post 3 weeks)	15	45.50 ± 2.16	
Group B	Cobb's Angle (Baseline)	16	47.20 ± 1.29	.009
	Cobb's Angle (Post 3 weeks)	15	46.86 ± 1.55	
Group A	Thoracic Extension (Baseline)	16	19.00 ± 2.44	.000
	Thoracic Extension (Post 3 weeks)	15	22.66 ± 1.63	
Group B	Thoracic Extension (Baseline)	16	19.73 ± 2.34	.001
	Thoracic Extension (Post 3 weeks)	15	20.46 ± 1.95	
Group A	Kyphotic Index relax posture (Baseline)	16	14.68 ± 0.45	.000
	Kyphotic Index relax posture (Post 3 weeks)	15	13.63 ± 0.25	
Group B	Kyphotic Index relax posture (Baseline)	16	15.04 ± 0.66	.000
	Kyphotic Index relax posture (Post 3 weeks)	15	14.63 ± 0.67	
Group A	Kyphotic best relax posture (Baseline)	16	13.70 ± 0.43	.000
	Kyphotic best relax posture (Post 3 weeks)	15	12.26 ± 0.28	
Group B	Kyphotic best relax posture (Baseline)	16	14.60 ± 0.75	.000
	Kyphotic best relax posture (Post 3 weeks)	15	14.25 ± 0.72	

Group A	ROTPDQ (Baseline)	16	38.53 ± 3.99	.000
	ROTPDQ (Post 3 weeks)	15	21.86 ± 3.46	
Group B	ROTPDQ (Baseline)	16	40.46 ± 3.97	.000
	ROTPDQ (Post 3 weeks)	15	33.20 ± 4.41	

NPRS: Numeric Pain Rating Scale, ROTPDQ: Revised Oswestry Thoracic Pain Disability Questionnaire

Table number 6 displays the with-in Group comparison of pre and post intervention on thoracic stiffness index. A statistical significant disparity (p-value<0.05) was found in pre and post intervention value of groups A after intervention of 3 weeks. But no significant disparity (p-value=0.317) was found in pre and post intervention value of groups B after intervention of 3 weeks.

Table 6: Within Group Comparison of Thoracic Stiffness Index (Wilcoxon Test)

Study Groups	N	Z value	Sig. Value
Group A (Post 3 weeks)	15	-3.369	0.001
Group B (Post 3 weeks)	15	-1.000	0.317

DISCUSSION

The present research trail objectives was to compare the effects of thoracic extension and thoracic stabilization regime and its impact on stiffness, pain, range of motion, posture and disability in patients with Maigne's syndrome. Results of the study shows that a statistical significant disparity (p-value<0.05) was found on NPRS, Cobb's angle, thoracic extension, kyphotic index relax posture, kyphotic best relax posture, thoracic stiffness index and ROTPDQ in both groups (A and B) after intervention of 3 weeks. Thoracic extension exercises were found to be more effective as compared to thoracic stabilization exercises in managing pain, stiffness and disability along with improving range of motion and posture in patients with Maigne's thoracic pain than thoracic stabilization exercises.

Chronic upper thoracic pain is not limited to progression of pain only. Along comes, disability, posture mal-alignment, improper biomechanics and compression of nerves. Therefore, in the present study kyphosis index relax posture and Revised Oswestry Thoracic Pain Disability Questionnaire was measured before and after intervention to assess the impact of thoracic spine deformity. This is in accordance to the study of Won- gyo 2013, the study was aimed to

correction of Cobb's angle and thoracic pain. Results of study were similar to current study analysis. Cobb's angle reduced to 40 degrees as compared to initial value of 47 degrees whereas in present study it reduced to 45 degreesas compared to 47 degrees pre-intervention. Significant improvement in prior study could be because of prolonged intervention program.[10]

Thoracic extension exercise regime worked on postural rehabilitation and normal kyphosis angle that could be the reason for alleviation of pain much more in group A than group B. Although improvement was also observed in stabilization but not significant enough. This is backed by research of Juchul chu et al in 2017 who preferred spine mobilization along with extension and stabilization regime to counter immobility and reduced quality of life. Prior study results showed significance p value less than 0.005 similar to current study significance value.[16]

Due to diverse functional impairments, patients with Maigne's syndrome suffer from reduced quality of life and more prone to disability. ROTPDQ was evaluated before and after intervention in both groups to assess the effectiveness of both interventions. Disability further results in balance and stability issues mostly in elderly populations. Group A saw sudden decrease in disability index by 17 points as compared to clinical group which observed decrease of 6 points. Both groups responded well to interventions. This is supported by previous study of Keun Se et al which results specified improvement of thoracic spine pain.[17]

Thoracic extension exercises works on improving thoracic mobility and correction of normal kyphosis angle by improving normal ranges. To counter overall postural deformity, stabilization group targeted muscles of scapula and cervical in order to smooth down link from above muscles to thoracic. Chin tuck in and draw in maneuver was instructed for thoracic stabilization and prone thoracic extension was instructed to Group A. Substantial improvement was observed in thoracic extension that is experimental group as compared to other group. Post-treatment measure for thoracic extension improved from 19 to 22 in group A whereas to 20 degrees in Group B. This is in correspondence to previous literature which also observed difference of NPRS for 1.4 points. On contrary this current study observed difference of 5 points that is considerably much effective than results of prior study. This contrast was developed because previous literature enrolled participants who were excessive smart phone users and they suffered from work related musculoskeletal disorders. It should be noteworthy that thoracic stabilization in clinical group also highlighted positive post treatment measures.[11]

The study was conducted for 3 weeks only and long term impacts were not analyzed. The effects of thoracic spine extension and thoracic stabilization techniques were only seen on individuals who had Maigne's thoracic pain, so results may not be generalizable to other conditions.

CONCLUSION

In conclusion, thoracic extension exercises were found to more effective than thoracic stabilization exercises in managing pain, stiffness and disability along with improving range of motion and posture in patients with Maigne's thoracic pain.

Recommendation: A longitudinal study is recommended with multiple assessments on several points of time in between along with follow- up, to evaluate long term effects of both thoracic extension exercises and thoracic stabilization exercises. Clinicians are suggested to incorporate thoracic extension exercises in treatment regime of Maigne's thoracic pain. Patients of Maigne's thoracic pain are recommended to add extension exercises in their lifestyle for management of their pain, disability and postural imbalance.

Financial support: This trial received no funding.

Competitive Interests: No conflict of interest.

Declaration of patient consent: Written consent was taken from all study participants.

Use of AI: None

Ethical approval: The study was approved by "Riphah International University, Lahore Campus" Research and Ethics Committee (ref no: REC/RCR & AHS/22/0134) on 04 March 2022. This randomized clinical trial was registered in NIH Clinical Trial Library U.S Reference number: **NCT05395078**.

Acknowledgment: We would like to thank all study participants for their voluntary participation.

REFERENCES

1. Randhawa S, Garvin G, Roth M, Wozniak A, Miller T. Maigne syndrome–a potentially treatable yet underdiagnosed cause of low back pain: a review. Journal of Back and Musculoskeletal Rehabilitation. 2022;35(1):153-9.

2. Masooma K, Naweed J, Razzaq M, Latif N, Wali S. Frequency of Upper Back Pain and its causes among Female Beauticians in Islamabad Pakistan: JRCRS. 2020; 8 (2): 56-60. Journal Riphah College of Rehabilitation Sciences. 2020;8(2):56-60.

3. Moustafa IM, Shousha TM, Walton LM, Raigangar V, Harrison DE. Reduction of thoracic hyper-kyphosis improves short and long term outcomes in patients with chronic nonspecific neck pain: a randomized controlled trial. Journal of Clinical Medicine. 2022;11(20):6028.

4. Koelé M, Lems W, Willems H. The clinical relevance of hyperkyphosis: a narrative review. Frontiers in endocrinology. 2020;11:5.

5. Moon H, Lee S-K, Kim W-M, Seo Y-G. Effects of exercise on cervical muscle strength and cross-sectional area in patients with thoracic hyperkyphosis and chronic cervical pain. Scientific reports. 2021;11(1):3827.

6. Czaprowski D, Stoliński Ł, Tyrakowski M, Kozinoga M, Kotwicki T. Non-structural misalignments of body posture in the sagittal plane. Scoliosis and spinal disorders. 2018;13:1-14.

7. Puntumetakul R, Chalermsan R, Hlaing SS, Tapanya W, Saiklang P, Boucaut R. The effect of core stabilization exercise on lumbar joint position sense in patients with subacute non-specific low back pain: a randomized controlled trial. Journal of physical therapy science. 2018;30(11):1390-5.

8. Kamali F, Shirazi SA, Ebrahimi S, Mirshamsi M, Ghanbari A. Comparison of manual therapy and exercise therapy for postural hyperkyphosis: a randomized clinical trial. Physiotherapy theory and practice. 2016;32(2):92-7.

9. Levine NA, Rigby BR, editors. Thoracic outlet syndrome: biomechanical and exercise considerations. Healthcare; 2018: MDPI.

10. Yoo W-g. Effect of thoracic stretching, thoracic extension exercise and exercises for cervical and scapular posture on thoracic kyphosis angle and upper thoracic pain. Journal of physical therapy science. 2013;25(11):1509-10.

11. Çelenay ŞT, Kaya DÖ. An 8-week thoracic spine stabilization exercise program improves postural back pain, spine alignment, postural sway, and core endurance in university students: a randomized controlled study. Turkish journal of medical sciences. 2017;47(2):504-13.

12. Isu T, Kim K, Morimoto D, Iwamoto N. Superior and middle cluneal nerve entrapment as a cause of low back pain. Neurospine. 2018;15(1):25.

13. Kang N-Y, Im S-C, Kim K. Effects of a combination of scapular stabilization and thoracic extension exercises for office workers with forward head posture on the craniovertebral

angle, respiration, pain, and disability: A randomized-controlled trial. Turkish journal of physical medicine and rehabilitation. 2021;67(3):291.

14. Piri H, Hajian M, Mirkarimpour SH, Sheikhhoseini R, Rahimi M. The effect of 12-week corrective exercises on the postural angles of beautician females with upper crossed syndrome: a clinical trial study. Women's Health Bulletin. 2021;8(2):91-7.

15. Fairbank J. Revised Oswestry disability questionnaire. Spine. 2000;25(19):2552.

16. Cho J, Lee E, Lee S. Upper thoracic spine mobilization and mobility exercise versus upper cervical spine mobilization and stabilization exercise in individuals with forward head posture: a randomized clinical trial. BMC musculoskeletal disorders. 2017;18:1-10.

17. Lee K-S, Lee J-H. Effect of Maitland mobilization in cervical and thoracic spine and therapeutic exercise on functional impairment in individuals with chronic neck pain. Journal of physical therapy science. 2017;29(3):531-5.