Effects of Spinal Manipulation on Thoracic Range of Motion, Chest Expansion, and Functional Status in Patients with Thoracic Spinal Pain: A Randomized Controlled Trial

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ABSTRACT

Purpose: To compare immediate and long-term effects of thoracic spine manipulation on thoracolumbar range of motion, functional status, and chest expansion in patients with thoracic pain.

Methods: A double-blind randomized clinical trial was conducted at Services Hospital, Lahore, Pakistan. There were 100 patients with an age range of 40–60 years included in the study after obtaining their consent. In the experimental group (n = 50), thoracic spinal manipulation was applied. The control group (n = 50) performed thoracic muscles exercises only. Thoracic mobility was measured with an inclinometer, functional status was measured by the Oswestry Disability Index, and chest expansion was measured by tape measure. Measurements were taken at baseline, after the first session, after the eighth session, and at later follow-ups after 8 and 12 weeks. Repeated measure ANOVA for in-group comparisons and the independent sample t-test for between-group comparisons were used. Intention-to-treat analysis was used to analyze the missing data due to loss of follow-up.

Results: Of the 100 enrolled patients, there were 35 male (70%) subjects in the control group and 34 males (68%) in the experimental group. The mean age of patients in the control group was 38.56±12.44 and 36.02±11.32 in the experimental group. Both groups demonstrated significant improvement in functional status, chest expansion, and thoracolumbar mobility compared to the baseline ($p < 0.05$) but an in-group comparison of the eighth session and results at the first and second follow-ups showed that effects of exercise persist while functional status and thoracolumbar mobility in the spinal manipulation group were significantly reduced after discontinuing treatment. The difference between both protocols was found to be a function of time. After the first and eighth sessions, spinal manipulation showed notable results, but at week 8 at the follow-up and week 12 at the second follow-up, no significant difference was observed between the study groups.

Conclusion:

Spinal manipulation and thoracic exercise together were more effective in comparison to thoracic exercises only in thoracic spine pain patients for improving their thoracic range of motion, chest expansion, and functional status at the end of 8th session of care. The addition of spinal manipulation to thoracic exercises was not advantageous or effective at the 12-week of follow-up because improvement was not sustained.

Keywords: Health status, Manual therapy, Range of motion, Spinal manipulation, Spinal column

INTRODUCTION

Spinal pain affects billions of individuals worldwide and is a leading cause of disability. In comparison to pain in the cervical and lumbar spine, thoracic spine pain is equally disabling even if its prevalence is low.[1] Spinal pain can severely limit physical ability and social well-being.[2] Conservative interventions are used for the management of spinal pain, including massage, exercises, and manual therapy, but lack of information and high-quality studies about appropriate treatment options often pose challenges.[3]

Spinal joint manipulation is defined as a "high-velocity low-amplitude (HVLA) intervention that separates vertebral joint surfaces and is performed at the end range of motion, often used by physiotherapists for the management of musculoskeletal pain". In this technique, cavitation usually occurs and may be accompanied by a popping sound. Clinical practice guidelines suggest that it is an important therapeutic tool.[4] It decreases intra-disc pressure and stretches the muscles of the surrounding area, thus producing relaxation.[5,6]

Spinal manipulation (HVLA) has long been studied because of its clinical effectiveness in other areas, such as for neck pain, low back pain, headaches, and restricted thoracic spine mobility, and thoracic spine manipulation is often considered the treatment of choice.[7] This method of treatment has a pain modulating effect by employing analgesia through changing neural sensitivity or via changing endogenous substances and increasing the pain threshold.[8] Patients often report immediate improvement in pain compared with other forms of therapies.[9]

As a prerequisite for daily activities, adequate spinal mobility is necessary. The decline in mobility leads to diminished physical performance. Spinal manipulation, mobilization, exercises, analgesics, and other electrical modalities are used to provide some short-term relief. Spinal manipulation, in particular, confers marginal benefits over other types of treatments. Evidence also suggests that manipulation improves function, probably by decreasing pain and increasing motion.[10] The effects are also seen in the improvement of chest expansion, which may be restricted because of pain and decreased mobility of the thoracic spine.[11]

As a therapeutic tool, this technique is inexpensive and is known to have a significant effect on pain and increasing functional status. Previous studies have compared the effects of thoracic and cervical spinal mobilization on low back pain, but there is a lack of evidence of immediate and long-term effects of thoracic spine manipulation on the mobility of the thoracic spine, chest expansion, and functional status.

MATERIALS AND METHODS

Study Design

A randomized trial was conducted with parallel groups. Participants who were willing to participate in the study were included from the Physiotherapy Department Services of Hospital Lahore, Pakistan. They were randomly allocated into two groups by a computer-generated randomization table. The Sequentially-Numbered, Opaque, Sealed Envelopes (SNOSE) method was used for concealment of allocation. The envelopes were prepared by an independent researcher with no clinical involvement. Except for the therapist who was giving treatment, all other staff including assessors and participants were blinded to the given treatment.

Participants, therapists, centers

A total of 127 subjects were assessed for inclusion in the study, of which 100 male and female participants between the age of 40–60 years who had nonspecific thoracic spine pain in T1 to T12 region with mobility deficits in thoracic spinal range of motion and pain with compression in the thoracic spine were included in the study. All others who had a contraindication to manual therapy including osteoporosis, thoracic fracture, spinal infection, neoplastic disorders, spondyloarthropathy, clinical examination suggestive of disc herniation, and history of visceral conditions referring to pain to the thoracic spine were excluded from the study. Written informed consent was obtained from all the participants.

Intervention

The thoracic spinal manipulation technique was used in the experimental group. The technique was considered successful when an auditory or palpable release was detected. Manipulation was administered by a physiotherapist with 13 years of clinical experience. In the control group, only thoracic spinal muscle exercises were applied with three sets of 10 repetitions with a rest period of 1 min between the sets. The patients performed exercises in the sitting and lying positions, using a medium-resistance TheraBand. Scapular retraction exercises were performed in a sitting position with elbows bent at 90 degrees, and the subjects pulled the TheraBand backward to move shoulder blades toward each other.[12] A second exercise was performed in a prone position with lower extremities stabilized, arms flexed, and thoracic spine extended.[13,14] The third exercise for thoracic rotation was performed in a sitting position with the TheraBand around the arms. The fourth exercise was performed in a sitting or lying position with trunk side flexion. Both groups received ergonomic advice for maintaining the correct anatomical posture.

Participants were treated twice a week for 4 weeks for a total of eight sessions. Measurements for chest expansion and thoracolumbar range of motion were taken at baseline, after the first session, and after the eighth session. Measurements on the Oswestry Disability Index (ODI) were taken at baseline and after the eighth session. Patients were followed up at the eighth week (second month) and the 12^{th} week after treatment to check the long-term effects.

Outcome measures

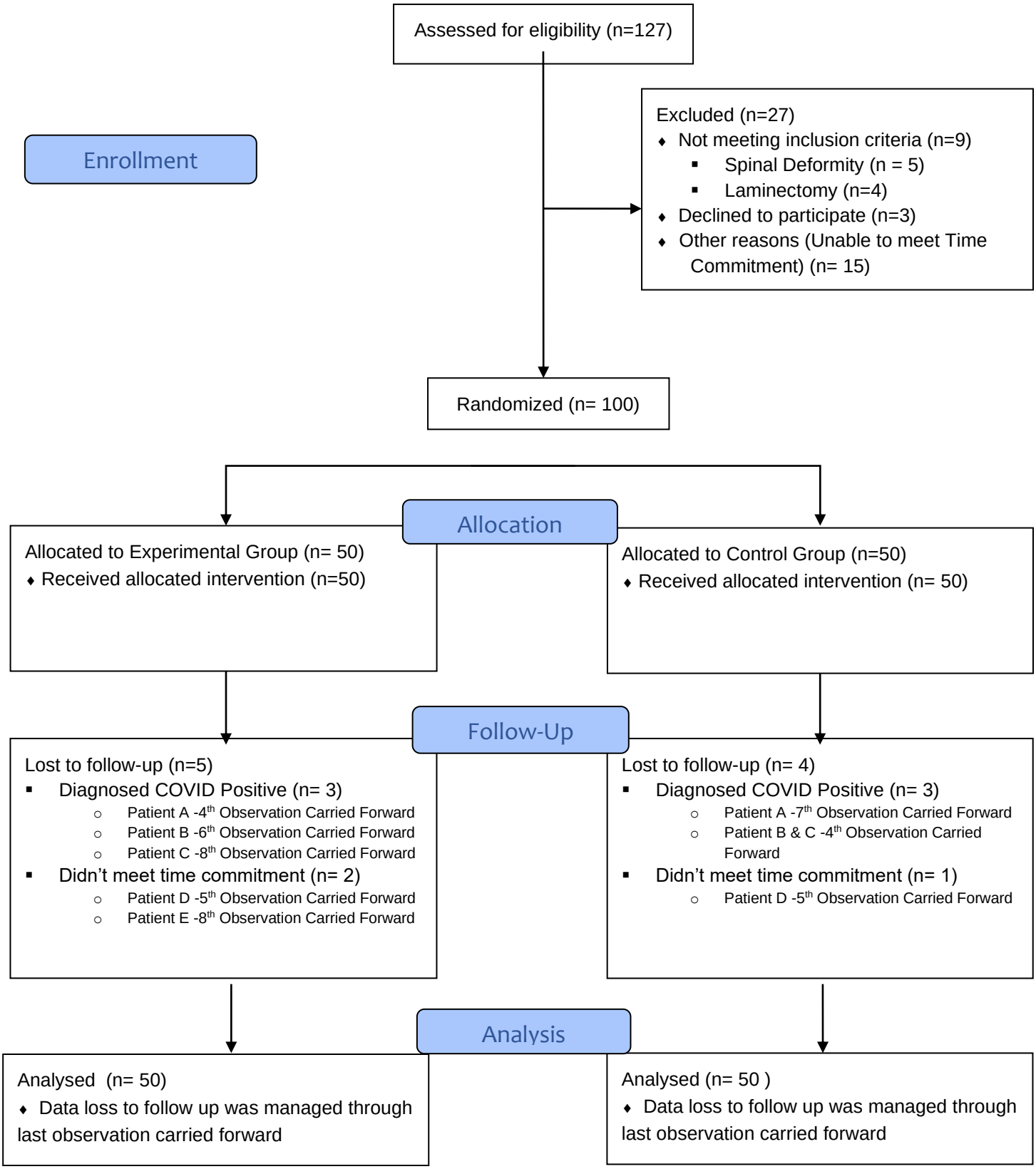
The outcomes were measurements of the effectiveness of the thoracic spinal manipulation technique on functional status, mobility, and chest expansion in participants with thoracic spinal

pain. Functional status was measured with ODI, thoracic mobility was measured with an inclinometer, and chest expansion was measured with a tape measure. Chest expansion was measured at one anatomic place, at the level of the 5^{th} thoracic spinous process (axillary level). Subjects were asked to take a deep breath and hold it while the measurement was taken.

Data analysis

Data were analyzed using SPSS version 23. Descriptive analyses (mean, variance, standard deviation) were performed for quantitative data. Frequencies and percentages were calculated for categorical and nominal data on gender. Data were analyzed for normality by applying the Shapiro-Wilk test. The independent sample t-test was used for between-group comparisons. Repeated measure ANOVA was used for in-group analysis. A p-value ≤ 0.05 was considered significant. Intention-to-treat analysis with the technique of last observation carried forward (LOCF) was used to analyze the missing data due to lack of follow-up.

CONSORT Flow Sheet Diagram



Results

Of 50 subjects, 35 (70%) were male in the control group and 34 (68%) were male in the experimental group. Mean age of patients in the control group was 38.56±12.44 and in the experimental group 36.02±11.32. Baseline values of age other outcome measures was comparable in both groups (Table 1).

Across the group comparison between control and experimental group showed significant difference between the two groups after first and eight sessions for ODI, chest expansion and thoracolumbar range of motion (P value < 0.05). (Table 2) However, no statistically significant difference was observed at three months follow up between the two treatment groups (P value > 0.05). (Table 2) There was statistically significant difference within experimental and control from baseline to follow up, for ODI, chest expansion and thoracolumbar range of motion (P value < 0.05). (Table 2)

Table 1 Baseline comparison of the mean (SD) of age, ODI scores, chest expansion, and thoracolumbar range of motion between control and experimental groups

	Control (n = 50)	Experimental (n = 50)	Mean difference (95% CI)	p-value
Age (years)	38.56 (12.44)	36.02 (11.32)	2.54 (2.18, 7.26)	0.28
ODI score	32.12 (11.19)	31.54 (10.27)	0.58 (-3.68,4.84)	0.78
Chest expansion	2.55 (0.52)	2.53(0.39)	0.01 (-0.16, 0.20)	0.84
Thoracolumbar flexion	28.90 (13.45)	27.88 (8.53)	1.02 (-3.45, 5.49)	0.65
Thoracolumbar extension	21.18 (6.43)	21.44 (6.63)	0.26 (-2.85, 2.33)	0.84
Thoracolumbar right side flexion	19.54 (5.97)	21.60 (6.28)	2.06 (-4.49, 0.37)	0.09
Thoracolumbar left side flexion	20.06 (6.83)	21.12 (6.76)	1.06 (-3.75, 1.63)	0.43
Thoracolumbar right rotation	15.08 (6.58)	15.82 (4.99)	0.74 (-3.06, 1.58)	0.52
Thoracolumbar left rotation	14.74 (6.29)	15.38 (5.00)	0.64 (-2.89, 1.61)	0.57

Table 2: Across and within the group comparison for ODI, chest expansion and thoracolumbar range of motion after 1st session, 8th session and 3 months follow up.

Outcome Measure	Groups	Baseline (n = 50)	After 1st session (n = 50)	After 8th session (n = 50)	Follow up at 3 months (n = 50)	p-value	Across the Group Mean Diff (95% CI)		
							After 1st session	After 8th session	Three-month
ODI	Control	32.12 (11.19)	xxxxxx	16.1 (6.80)	16.88 (6.63)	<0.05	XXXXXXX	2.20* (0.30, 4.70)	0.74 (-3.31, 1.83)
	Experimental	31.54 (10.27)	xxxxxx	13.92 (5.75)	17.62 (6.33)	<0.05			
Chest expansion (cm)	Control	2.55 (0.52)	2.97 (0.44)	3.31 (0.41)	3.25 (0.41)	<0.05	0.18* (-0.002,0.36,)	0.29* (0.14,0.44,)	0.17 (-0.34, -0.01)
	Experimental	2.53 (0.39)	3.15 (0.46)	3.61 (0.36)	3.43 (0.42)	<0.05			
Thoracolumbar flexion	Control	28.90 (13.45)	35.60 (14.55)	41.38 (12.16)	40.26 (6.28)	<0.05	2.04 (-6.45, 2.37)	3.92* (0.34,7.87)	1.16 (-1.28, 3.60)
	Experimental	27.88 (8.53)	37.64 (5.94)	45.30 (7.12)	39.10 (6.02)	<0.05			
Thoracolumbar extension	Control	21.18 (6.43)	26.96 (6.42)	32.44 (6.39)	31.16 (6.03)	<0.05	2.48* (0.28,4.93,)	8.48* (5.87,11.08)	0.24 (-2.56, 2.08)
	Experimental	21.44 (6.63)	29.44 (5.92)	40.92 (6.70)	31.40 (5.67)	<0.05			
Thoracolumbar right-side flexion	Control	19.54 (5.97)	23.78 (5.69)	29.62 (4.75)	28.52 (5.20)	<0.05	2.50 * (0.27,4.72,)	2.08* (0.06,4.09)	0.54 (-1.53, 2.61)
	Experimental	21.60 (6.28)	26.28 (5.49)	31.70 (5.35)	27.98 (5.25)	<0.05			
Thoracolumbar left side flexion	Control	20.06 (6.83)	24.04 (5.42)	29.26 (4.79)	28.38 (5.18)	<0.05	2.74* (0.61,4.86,)	2.30* (0.37,4.26)	0.42 (-1.62, 2.46)
	Experimental	21.12 (6.76)	26.78 (5.27)	31.58 (4.99)	27.96 (5.13)	<0.05			
Thoracolumbar right rotation	Control	15.08 (6.58)	19.62 (7.05)	23.70 (5.45)	22.58 (5.00)	<0.05	3.60* (0.90,6.29)	4.18* (1.59,6.76)	0.42 (-1.35, 2.19)
	Experimental	15.82 (4.99)	23.22 (6.48)	27.80 (7.43)	22.16 (3.84)	<0.05			
Thoracolumbar left rotation	Control	14.74 (6.29)	18.62 (6.37)	23.08 (5.06)	22.04 (5.39)	<0.05	1.54* (0.61,3.69,)	3.64* (1.02,5.67)	0.04 (-1.78, 1.86)
	Experimental	15.38 (5.00)	20.16 (4.29)	26.72 (5.20)	22.00 (3. 66)	<0.05			

*Significant with P value < 0.05, [ODI: Oswestry Disability Index]

DISCUSSION

In this randomized controlled trial, findings overall suggest that thoracic spinal manipulation with exercise shows significant effects on functional ability, chest expansion, and thoracolumbar range of motion but in comparison to exercises alone it is not very effective upon follow up, consistent with the study of Méndez et al.[7]

Spinal manipulative therapy provokes hypoalgesia in the area of treatment and also at distant sites, thus promoting motion in other segments too. This phenomenon may be due to "regional interdependence."[15] Thus in this study, along with thoracic spinal mobility, lumbar spine mobility was also increased, which is measured as thoracolumbar spine mobility.

Most of the studies on a spinal range of motion have studied the cervical and lumbar spine. Few studies have measured the effects on thoracic spinal mobility. Spinal manipulation has been used for many years to relieve joint restriction and increase range of motion and decrease functional disability. This study showed an increase in thoracolumbar mobility in comparison between the control and experimental groups after the first and eighth sessions, demonstrating that chest expansion and most of the thoracolumbar range of motion have greater improvement in the spinal manipulation group, and there were statistically significant differences between both groups for most of the outcome measures, with p value < 0.05 which is similar to the study by Dennis.[16,17]

Manual therapy is an approach that can be used for the correction of functional and structural abnormalities. Thoracic manipulation is a high-velocity, low-amplitude maneuver that works by relaxing hypertonic muscles and by disrupting articular and periarticular adhesion, increasing mobility and helping the chest to expand. Results of this study are consistent with the study of Ganesh et al; comparison between control and experimental groups immediately after the first and then after the eighth session has shown that greater improvement in chest expansion was found in the spinal manipulation group. The mean difference between both the groups after the 1st session was 0.18 inches ($p = 0.04$) and after the 8th session, it was 0.29 inches ($p < 0.05$).[18] In another study by Maji et al, thoracic spine manipulation produced significant changes in chest expansion.[19]

Thoracic spinal manipulation has been shown to improve function and disability in other areas of the body.[20] The current study also showed improvement in functional status of patients in that comparing ODI in both groups showed that functional status was significantly improved after spinal manipulation as well as in the thoracic exercises group with $p < 0.05$.

Comparison of both groups at the first and second follow-up after 2 and 3 months after discontinuation of treatment showed that there were no statistically significant differences present in functional status and thoracolumbar mobility between both groups, with $p > 0.05$ for most of the variables. Group comparisons of different variables between the 8^{th} session and 1st follow-up showed that the effects of thoracic exercises in the control group persisted even after treatment was discontinued ($p > 0.05$), but functional status and thoracolumbar mobility were significantly reduced in the spinal manipulation group ($p < 0.05$). A plausible explanation of this finding could be that the clinical effects of the manipulative technique are short-term and immediate with little effect persisting at follow-ups.[21,22]

There are some potential limitations and strengths in this study. Firstly, the data was collected from a single setting and follow-up was just up to 3 months so future studies should be conducted based on several treatment sessions with even longer follow-ups. Secondly, the application of force should be assessed when it is applied for the spinal manipulation technique because no previous evaluation for vertebral dysfunction was made and the force applied in this technique

was not assessed, so dosage remains a matter of concern for further research. However, the cost-effective spinal manipulation technique can help people with thoracic spinal pain particularly in the short term, when more expensive modalities are unavailable. It could also be utilized as a combination with thoracic exercises to change the treatment protocols in clinical practice to have better results.

CONCLUSION

Spinal manipulation and thoracic muscles exercises are effective in improving functional status, chest expansion, and thoracolumbar range of motion in patients with thoracic pain. The comparison of short- and long-term differences between groups in functional status, chest expansion, and thoracolumbar range of motion favored thoracic spinal manipulation on a short-term basis but with little lasting effect at follow-ups. We recommend further studies exploring the short and long-term neurophysiological effects of spinal manipulative therapy.

Trial registration: This trial was registered in "Iranian Registry of Clinical Trials (IRCT 20190327043125N1).

Ethical approval: Ethical approval was obtained from the University of Lahore (Ref# IRB-UOL-FAHS/373-IIV/2018).

Conflicts of Interest: There are no conflict of interest

Data availability: Data can be made available on request.

Authors' Contribution:

1.	Concept development (provided idea for the research)	**Muhammad Sharif Waqas**
2.	Design (planned the methods to generate the results)	**Hossein Karimi** **Ashfaq Ahmed**
3.	Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript)	**Hossein Karimi** **Ashfaq Ahmed** **Muhammad Sharif Waqas**
4.	Data collection/processing	**Muhammad Sharif Waqas**

	(responsible for experiments, patient management, organization, or reporting data)	**Naveed Anwar**
5.	Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results)	**Muhammad Sharif Waqas** **Amna Zia**
6.	Literature search (performed the literature search)	**Muhammad Sharif Waqas** **Shazia Rafiq** **Amna Zia**
7.	Writing (responsible for writing a substantive part of the manuscript)	**Muhammad Sharif Waqas** **Shazia Rafiq**
8.	Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking)	**Hossein Karimi** **Ashfaq Ahmed** **Muhammad Sharif Waqas** **Naveed Anwar**
9.	Final approval of manuscript	**Hossein Karimi** **Ashfaq Ahmed** **Muhammad Sharif Waqas**

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