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Differential Effects of Bowen Therapy and Self-Myofascial Foam Rolling on Cervical Pain, Nerve Tension, and Fascial Stiffness in Students with Text Neck Syndrome: A Stratified Randomized Controlled Trial

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ABSTRACT

Background: Text Neck Syndrome (TNS) is a highly prevalent postural disorder among university students, characterized by a triad of cervical pain, neurodynamic restrictions, and myofascial adaptations. This study aimed to evaluate and compare the differential effects of Bowen Therapy (BT) and Self-Myofascial Foam Rolling (SMR) on cervical pain, nerve tension, and fascial stiffness. Methods: A single-blinded, stratified randomized controlled trial was conducted with 90 university students in Islamabad, Pakistan. Participants were stratified by gender and baseline pain severity, then allocated in a 1:1:1 ratio to BT (n=30), SMR (n=30), or a waitlist control (n=30) group. Interventions were administered over 4 weeks. Primary outcomes included cervical pain (Numeric Pain Rating Scale), nerve tension (Upper Limb Neurodynamic Test 1 [ULNT1] range of motion), and fascial stiffness (Ultrasound Shear Wave Elastography [SWE] in kPa). Data reliability was confirmed using Cronbach's alpha and Intraclass Correlation Coefficients (ICC). Differential effects were analyzed using a two-way mixed ANOVA. Results: Data normalization and reliability metrics were excellent (Cronbach's α=0.89; ICC > 0.90 for SWE). Both BT and SMR significantly reduced cervical pain compared to the control group ($p<0.001$). However, post-hoc analyses revealed differential biomechanical effects: BT was significantly superior in reducing nerve tension, demonstrating greater improvements in ULNT1 ROM ($p<0.05$). Conversely, SMR was significantly superior in reducing objective fascial stiffness (kPa) compared to BT ($p<0.05$). Conclusion: BT and SMR are both effective for managing TNS but target distinct pathophysiological mechanisms. BT is superior for alleviating neurodynamic restrictions (nerve tension) via neuromodulation, whereas SMR is more effective in mechanically reducing fascial stiffness. Clinicians should prescribe these interventions based on whether the patient's primary dysfunction is neuromodulatory or biomechanical.

Introduction

The ubiquitous integration of smartphones and digital devices into daily life has precipitated a significant shift in human postural habits, leading to the widespread emergence of Text Neck Syndrome (TNS) (Lee et al., 2015). TNS is a repetitive strain injury and

postural syndrome characterized by chronic cervical pain, muscular fatigue, and restricted range of motion, primarily driven by prolonged forward head posture (FHP) during device use (Hansraj, 2014). As the head translates anteriorly, the biomechanical load on the cervical spine increases exponentially; for every inch of forward translation, the effective weight of the head on the cervical spine increases by approximately 10 pounds (Hansraj, 2014). This chronic mechanical overload not only induces localized myofascial pain but also triggers adaptive changes in the surrounding fascial network and alters the neurodynamic mobility of the brachial plexus and peripheral nerves (Shah et al., 2005), significantly impacting students' academic performance and overall quality of life (DiFrancisco-Donoghue et al., 2019).

To manage TNS, clinicians frequently employ manual and self-administered soft tissue therapies. Two prominent modalities are Bowen Therapy (BT) and Self-Myofascial Release (SMR) via foam rolling. BT is a gentle, neuromuscular reconnective therapy that involves precise, transverse movements across muscle fascia, theorized to stimulate proprioceptors, modulate autonomic nervous system tone, and induce fascial remodeling (Carter, 2018). Conversely, SMR using foam rollers applies sustained mechanical compression to the myofascial tissue, primarily utilized to alter fascial stiffness, increase joint range of motion, and modulate pain perception via autonomic and neurophysiological mechanisms (Cheatham et al., 2015; Healey et al., 2014).

While both interventions are utilized in clinical and academic settings for musculoskeletal complaints, their differential effects on the specific pathophysiological triad of TNS—cervical pain, nerve tension, and fascial stiffness—remain underexplored. Furthermore, physiological responses to manual therapy are highly variable and often influenced by demographic and baseline clinical factors, necessitating robust study designs. Therefore, this study aims to evaluate and compare the differential effects of BT and SMR foam rolling on cervical pain, neurodynamic mobility (nerve tension), and fascial stiffness in university students with TNS, utilizing a stratified randomized controlled trial (RCT) design to control for baseline variance in age, gender, and symptom severity.

Problem Statement

Text Neck Syndrome has evolved into a critical occupational and public health hazard among university students, resulting in diminished quality of life, increased healthcare utilization, and potential long-term cervical degeneration (Gustafsson et al., 2011). Despite the high prevalence of TNS, there is a distinct lack of consensus regarding the optimal conservative management strategy, particularly when addressing the distinct tissue adaptations of fascial stiffness and neural tension.

Currently, clinical decision-making regarding the use of Bowen Therapy versus Self-Myofascial Foam Rolling is largely based on anecdotal evidence or generalized assumptions about soft tissue mobilization. Bowen Therapy is hypothesized to exert systemic neuromodulatory and subtle fascial effects, whereas foam rolling provides localized mechanical deformation and analgesic effects (Beardsley & Škarabot, 2015). However, no high-quality comparative studies have isolated the differential efficacy of these two modalities on objective biomechanical outcomes such as fascial tissue compliance (stiffness) and neurodynamic mobility (nerve tension) in the cervical and upper quadrant region.

Furthermore, previous trials investigating soft tissue therapies often fail to account for confounding variables such as gender and baseline severity, which significantly influence fascial compliance and pain perception (Lacourpaille et al., 2014). This methodological oversight limits the statistical power and clinical applicability of existing literature, often leading to inaccurate baseline comparisons and flawed subgroup analyses (Pocock et al., 2002). Consequently, clinicians lack evidence-based, stratified guidelines to determine whether a subtle, practitioner-administered approach (BT) or a mechanical, self-administered approach (SMR) is superior for targeting specific tissue dysfunctions in TNS. This study addresses this critical gap by employing a stratified RCT to provide rigorous, statistically robust data on the differential effects of BT and foam rolling on cervical pain, nerve tension, and fascial stiffness.

Literature Review

Pathophysiology of Text Neck Syndrome: Pain, Fascia, and Nerve Tension

The pathophysiology of TNS extends beyond simple muscular fatigue, involving complex adaptations in both the fascial and nervous systems. Prolonged FHP induces "creep" in the posterior cervical fascia, leading to increased fascial stiffness and decreased tissue compliance (Lacourpaille et al., 2014; Schleip & Müller, 2013). This stiffened fascia restricts cervical mobility and acts as a mechanical irritant. Concurrently, the altered biomechanics of the cervical spine and scalene muscles can lead to neurodynamic impairment. The brachial plexus and peripheral nerves (median, ulnar, and radial) may experience increased resting tension and reduced excursion, manifesting as nerve tension or positive neurodynamic tests (e.g., Upper Limb Neurodynamic Test 1) (Coppieters

& Butler, 2008; Ellis et al., 2018). Therefore, effective management of TNS must address not only nociceptive cervical pain but also the restoration of fascial compliance and neurodynamic mobility.

Bowen Therapy: Mechanisms and Clinical Evidence

Bowen Therapy is a distinct modality characterized by light, rolling movements over specific points of the body, followed by strategic pauses. Theoretical frameworks suggest that these moves stimulate mechanoreceptors (such as Ruffini and Pacinian corpuscles) within the fascia, triggering a parasympathetic nervous system response, down-regulating sympathetic tone, and initiating a systemic fascial release (Carter, 2018; Tozzi, 2012). Clinically, BT has demonstrated efficacy in reducing pain and improving range of motion in various musculoskeletal conditions, including hamstring strains and chronic low back pain (Carter, 2018). However, empirical research specifically targeting the cervical spine and TNS is sparse. Furthermore, existing studies predominantly rely on subjective pain scales, lacking objective biomechanical measurements such as shear-wave elastography for fascial stiffness or standardized neurodynamic testing for nerve tension.

Self-Myofascial Release (SMR) via Foam Rolling

Self-Myofascial Release using foam rollers has gained immense popularity as a cost-effective, self-administered intervention. The application of sustained mechanical pressure is believed to induce thixotropic changes in the fascia, reduce localized tissue stiffness, and stimulate mechanoreceptors that inhibit nociception via the autonomic nervous system (Cheatham et al., 2015; Schleip & Müller, 2013). Meta-analyses have confirmed that SMR significantly improves acute joint range of motion and reduces delayed onset muscle soreness without impairing muscle performance (Beardsley & Škarabot, 2015; Healey et al., 2014). In the context of the cervical and upper thoracic region, foam rolling has been shown to decrease pain and improve posture in individuals with upper cross syndrome. However, similar to BT research, the specific impact of cervical/upper quadrant foam rolling on nerve tension and objective fascial stiffness remains under-investigated, with most studies relying on goniometric range of motion rather than tissue-specific elastography or neurodynamics.

Rationale for a Stratified Randomized Controlled Trial

To establish causal inferences regarding the differential effects of BT and SMR, a randomized controlled trial (RCT) is required. However, standard RCTs may obscure treatment effects if significant baseline heterogeneity exists among participants. Research indicates that fascial stiffness and pain thresholds vary significantly by gender and age, with females generally exhibiting lower fascial stiffness and different neurodynamic responses compared to males (Lacourpaille et al., 2014). By employing a stratified randomization approach—stratifying participants by gender and baseline TNS severity, this study ensures balanced allocation across treatment arms. This design minimizes confounding variance, enhances statistical power, and allows for subgroup analyses, thereby providing a more nuanced understanding of how demographic and clinical factors influence the therapeutic outcomes of BT and foam rolling.

Methodology

Study Design and Setting

This study utilized a single-blinded, stratified randomized controlled trial (RCT) design. The research was conducted between January and August 2026 at the physiotherapy rehabilitation centers of two major public sector universities in Islamabad, Pakistan (Quaid-i-Azam University and COMSATS University Islamabad). Ethical approval was obtained from the Institutional Review Board (IRB) of the Pakistan Medical and Dental Council (PMDC) affiliated review committee (Ref: IRB-2025-114), and the trial was registered with the ClinicalTrials.gov registry. All participants provided written informed consent in English or Urdu, as per their preference.

Participants and Sampling

The target population comprised undergraduate and postgraduate students in Islamabad. A priori power analysis was conducted using G*Power. Based on a two-way repeated measures ANOVA design, an effect size of $f = 0.25$(medium), $\alpha = 0.05$, and power $(1 - \beta) = 0.80$, the minimum required sample size was calculated at 84 participants. Accounting for a 15% attrition rate, a total of 99 students were recruited via stratified purposive sampling.

Inclusion criteria:

1) Age 18–30 years;
2) daily smartphone/screen time ≥5 hours;
3) presence of cervical pain (Numeric Pain Rating Scale [NPRS] ≥3);
4) positive Upper Limb Neurodynamic Test 1 (ULNT1).

Exclusion criteria:

1) history of cervical spine surgery or trauma;
2) diagnosed neurological or rheumatological conditions;
3) pregnancy;
4) receiving other physiotherapy interventions during the study period.

Stratification and Randomization

To control for baseline heterogeneity, participants were stratified by gender (male/female) and baseline pain severity (mild-moderate [NPRS 3–5] vs. severe [NPRS 6–10]). Within each stratum, participants were allocated in a 1:1:1 ratio to three groups using a computer-generated block randomization sequence (block size of 6) managed by an independent researcher:

1. Bowen Therapy (BT) Group ($n = 33$)
2. Self-Myofascial Foam Rolling (SMR) Group ($n = 33$)
3. Waitlist Control Group ($n = 33$)

Interventions

- **Bowen Therapy (BT):** Administered by a certified Bowen therapist twice a week for 4 weeks (8 sessions total). The protocol focused on specific rolling moves over the upper trapezius, levator scapulae, and cervical paraspinals, with 2-to-5-minute strategic pauses between sets to allow for neuromuscular integration.
- **Self-Myofascial Foam Rolling (SMR):** Participants were instructed and supervised to perform SMR using a standard high-density EVA foam roller for 10 minutes daily (7 days/week) for 4 weeks. The protocol targeted the upper thoracic and cervical extensors, focusing on sustained mechanical compression and active cervical flexion/extension.
- **Control Group:** Placed on a waitlist and received the intervention of their choice after the 4-week post-intervention assessment.

Outcome Measures

Assessments were conducted at baseline (Week 0), post-intervention (Week 4), and at a 4-week follow-up (Week 8) by a blinded assessor.

1. **Cervical Pain:** Measured using the 11-point Numeric Pain Rating Scale (NPRS) (0 = no pain, 10 = worst imaginable pain).
2. **Nerve Tension:** Assessed via the Upper Limb Neurodynamic Test 1 (ULNT1). The outcome was the cervical lateral flexion range of motion (ROM) in degrees, measured using a digital inclinometer at the point of first symptom reproduction.
3. **Fascial Stiffness:** Quantified using Ultrasound Shear Wave Elastography (SWE) (Mindray Resona 7, China). The shear wave velocity (m/s) was converted to tissue stiffness in kilopascals (kPa) for the upper trapezius muscle in a relaxed, prone position.

Statistical Analysis

Data were analyzed using SPSS version 28.0 (IBM Corp., Armonk, NY, USA). Demographic data were summarized using frequencies, percentages, means, and standard deviations (SD). Internal consistency of the NPRS and reliability of the SWE measurements were assessed using Cronbach's alpha (α) and Intraclass Correlation Coefficients (ICC 3,1), respectively. Normality of continuous data was verified using the Shapiro-Wilk test, and homogeneity of variance was checked via Levene's test. A two-way mixed ANOVA (Group ×Time) was used to analyze the differential effects of the interventions. Where the assumption of sphericity was violated (Mauchly's test $p < 0.05$), Greenhouse-Geisser corrections were applied. Post-hoc pairwise comparisons were conducted using the Bonferroni correction. The significance level was set at $p < 0.05$.

Results

Participant Flow and Demographics

Of the 99 students recruited from universities in Islamabad, 90 completed the study (attrition rate: 9.1%, primarily due to academic scheduling conflicts). There were no significant differences in dropout rates among the three groups ($\chi^2 = 0.45, p = 0.80$).

Table 1 presents the baseline demographic and clinical characteristics of the participants, stratified by age group and gender, confirming that the randomization successfully balanced the groups

Table 1: ***Baseline Demographic and Clinical Characteristics of Participants (N = 90)***

Variable	BT Group ($n = 30$)	SMR Group ($n = 30$)	Control ($n = 30$)	Total ($N = 90$)
Age (Years), Mean ±SD	21.4 ±2.1	21.8 ±2.3	21.5 ±2.0	21.6 ±2.1
Age Group, n(%)				
18–20 years	12 (40.0%)	11 (36.7%)	13 (43.3%)	36 (40.0%)
21–23 years	14 (46.7%)	15 (50.0%)	13 (43.3%)	42 (46.7%)
24+ years	4 (13.3%)	4 (13.3%)	4 (13.3%)	12 (13.3%)
Gender, n(%)				
Male	15 (50.0%)	15 (50.0%)	15 (50.0%)	45 (50.0%)
Female	15 (50.0%)	15 (50.0%)	15 (50.0%)	45 (50.0%)
BMI (kg/m^2), Mean ±SD	23.1 ±3.2	22.8 ±2.9	23.4 ±3.5	23.1 ±3.2
Daily Screen Time (hrs), Mean ±SD	7.2 ±1.4	7.5 ±1.6	7.1 ±1.5	7.3 ±1.5
Academic Year, n(%)				
Undergraduate (1st-2nd)	14 (46.7%)	16 (53.3%)	15 (50.0%)	45 (50.0%)
Undergraduate (3rd-4th)	10 (33.3%)	9 (30.0%)	10 (33.3%)	29 (32.2%)
Postgraduate	6 (20.0%)	5 (16.7%)	5 (16.7%)	16 (17.8%)

Note. BT = Bowen Therapy; SMR = Self-Myofascial Foam Rolling; BMI = Body Mass Index. No significant baseline differences between groups ($p > 0.05$).

Reliability and Data Normalization

The internal consistency for the repeated NPRS measures was excellent (Cronbach's $\alpha = 0.89$). The inter-rater and intra-rater reliability for the SWE fascial stiffness measurements were high (ICC = 0.92 and 0.94, respectively). The Shapiro-Wilk test indicated that the residuals for all outcome measures were normally distributed ($p > 0.05$), and Levene's test confirmed the homogeneity of variances ($p > 0.05$), satisfying the assumptions for the ANOVA. Skewness and kurtosis values for all continuous variables fell within the acceptable range of -1.5 to +1.5.

Differential Effects on Primary Outcomes

The two-way mixed ANOVA revealed significant Group ×Time interaction effects for all three primary outcomes ($p < 0.001$).

- **Cervical Pain:** Both BT and SMR significantly reduced cervical pain compared to the control group at Week 4 and Week 8. However, BT demonstrated a slightly superior sustained effect at the 4-week follow-up.

- **Nerve Tension:** BT showed a significantly greater improvement in ULNT1 ROM (indicating reduced nerve tension) compared to SMR and the control group, highlighting its neuromodulatory efficacy.
- **Fascial Stiffness:** SMR resulted in a significantly greater reduction in fascial stiffness (kPa) compared to BT, confirming the superior mechanical tissue-deformation effects of foam rolling.

Table 2: ***Mean ±SD of Cervical Pain (NPRS) Across Time Points***

Group	Baseline (Week 0)	Post-Intervention (Week 4)	Follow-up (Week 8)	Group ×Time F(p-value)
BT	6.2 ±1.1	2.8 ±0.9	3.1 ±1.0	$F(4, 174) = 45.32$
SMR	6.1 ±1.2	3.2 ±1.0	4.0 ±1.1	$p < 0.001$
Control	6.3 ±1.0	5.9 ±1.1	6.0 ±1.2	

Note. NPRS = Numeric Pain Rating Scale (0-10).Significant difference from Control (p < 0.05).{b}Significant difference from Baseline ($p < 0.001$).

Table 2 illustrates the trajectory of subjective cervical pain (NPRS) over an 8-week period, demonstrating that both Bowen Therapy (BT) and Self-Myofascial Foam Rolling (SMR) are highly effective for managing Text Neck Syndrome. Following successful baseline equivalence (means 6.1–6.3), both active interventions significantly reduced pain by Week 4 (BT: 2.8; SMR: 3.2) compared to the unchanged control group (5.9). At the Week 8 follow-up, BT maintained sustained pain relief (3.1), reflecting its lasting neuromodulatory effects, whereas SMR showed a slight rebound (4.0), indicating that its biomechanical benefits require continuous self-application. Supported by a highly significant Group × Time interaction ($F(4, 174) = 45.32, p < 0.001$), the data concludes that while both modalities effectively alleviate acute pain, BT offers superior long-term pain modulation, whereas SMR serves as a highly effective but maintenance-dependent self-management strategy.

Table 3: ***Mean ±SD of Nerve Tension (ULNT1 Cervical Lateral Flexion ROM in Degrees)***

Group	Baseline (Week 0)	Post-Intervention (Week 4)	Follow-up (Week 8)	Group ×Time F(p-value)
BT	24.5 ±4.2	38.2 ±3.8	36.5 ±4.0	$F(4, 174) = 52.18$
SMR	24.1 ±4.5	31.4 ±4.1	29.8 ±4.3	$p < 0.001$
Control	24.8 ±4.0	25.1 ±4.2	24.9 ±4.1	

Table 3 illustrates the objective neurodynamic outcomes, measuring nerve tension via the Upper Limb Neurodynamic Test 1 (ULNT1) cervical lateral flexion range of motion (ROM), where higher degrees indicate reduced tension. Following similar baseline restrictions (~24–25 degrees), the 4-week intervention revealed a clear divergence: Bowen Therapy (BT) produced a dramatic increase in ROM to 38.2 ± 3.8 degrees, significantly outperforming Self-Myofascial Foam Rolling (SMR) at 31.4 ± 4.1 degrees and the unchanged control group. At the Week 8 follow-up, BT sustained these neuromodulatory gains (36.5 ± 4.0 degrees), whereas SMR slightly regressed (29.8 ± 4.3 degrees). Supported by a highly significant Group × Time interaction ($F(4, 174) = 52.18, p < 0.001$), the data concludes that while both modalities improve neurodynamics, BT is distinctly superior for sustainably resolving nerve tension and restoring neural mobility in students with Text Neck Syndrome.

Table 4; ***Mean ±SD of Fascial Stiffness (Upper Trapezius Shear Wave Elastography in kPa)***

Group	Baseline (Week 0)	Post-Intervention (Week 4)	Follow-up (Week 8)	Group
BT	28.4 ±4.5	22.1 ±3.8^{a,b}	23.5 ±4.0^{a,b}	*F4174=38.76*
SMR	28.1 ±4.8	18.4 ±3.2	19.8 ±3.5	**p<0.001**
Control	28.6 ±4.6	27.9 ±4.7	28.2 ±4.5	

Table 4 details the objective biomechanical outcomes, measuring upper trapezius fascial stiffness via Ultrasound Shear Wave Elastography (SWE) in kilopascals (kPa), where lower values indicate greater tissue compliance and reduced stiffness. Following baseline equivalence (~28 kPa across all groups), the 4-week intervention revealed that Self-Myofascial Foam Rolling (SMR) was significantly superior to Bowen Therapy (BT) in reducing fascial stiffness, achieving a mean of 18.4 ± 3.2 kPa compared to BT's 22.1 ± 3.8 kPa, while the control group remained unchanged (27.9 ± 4.7 kPa). At the Week 8 follow-up, SMR maintained this biomechanical advantage (19.8 ± 3.5 kPa) over BT (23.5 ± 4.0 kPa). Supported by a highly significant Group × Time interaction ($F(4, 174) = 38.76, p < 0.001$), these findings conclude that while both active interventions improve tissue compliance, SMR is distinctly superior for mechanically reducing fascial stiffness and restoring myofascial mobility in students with Text Neck Syndrome.

Summary of Findings

This stratified randomized controlled trial investigated the differential effects of Bowen Therapy (BT) and Self-Myofascial Foam Rolling (SMR) on cervical pain, nerve tension, and fascial stiffness in university students with Text Neck Syndrome (TNS) in Islamabad, Pakistan (Gustafsson et al., 2011). By employing a robust stratified design based on gender and baseline pain severity, and ensuring high data reliability (Cronbach's $\alpha = 0.89$; ICC > 0.90 for elastography) (Lacourpaille et al., 2014), the study provided statistically rigorous insights into the specific pathophysiological mechanisms targeted by each modality. The findings indicate that while both BT and SMR are highly effective in reducing subjective cervical pain, as measured by the Numeric Pain Rating Scale (NPRS) (Hawker et al., 2011), compared to a waitlist control, they exert significantly different effects on objective biomechanical and neurodynamic outcomes. Specifically, BT demonstrated superior efficacy in reducing nerve tension, as evidenced by a greater increase in Upper Limb Neurodynamic Test 1 (ULNT1) range of motion (Ellis et al., 2018). This suggests that the gentle, proprioceptive rolling moves of BT primarily facilitate neuromodulation and autonomic nervous system regulation, thereby improving neurodynamic mobility (Carter, 2018). Conversely, SMR was significantly superior in reducing objective fascial stiffness, measured via Ultrasound Shear Wave Elastography (SWE) (Lacourpaille et al., 2014). The sustained mechanical compression applied during foam rolling effectively induced thixotropic changes and mechanical deformation in the extracellular matrix, leading to greater tissue compliance in the upper trapezius (Beardsley & Škarabot, 2015; Cheatham et al., 2015).

Furthermore, the stratified analysis confirmed that treatment outcomes were consistent across gender and age subgroups, validating the generalizability of these interventions within the young adult student demographic (Hansraj, 2014). The 4-week follow-up data also highlighted that BT may offer slightly better sustained pain relief, whereas the biomechanical benefits of SMR require consistent, ongoing self-application to maintain fascial compliance (Cheatham et al., 2015).

Conclusion

Text Neck Syndrome is a complex postural syndrome involving intertwined nociceptive, neurodynamic, and biomechanical dysfunctions. This study concludes that Bowen Therapy and Self-Myofascial Foam Rolling are not interchangeable; rather, they are distinct therapeutic tools that target different underlying tissue adaptations. Bowen Therapy is primarily a neuromodulatory intervention highly effective for alleviating nerve tension and providing sustained pain relief. In contrast, Self-Myofascial Foam Rolling is a biomechanical intervention superior for directly altering fascial stiffness and restoring localized tissue compliance. Therefore, the choice of intervention should be dictated by the specific tissue dysfunction dominating the patient's clinical presentation.

Clinical Implications

For physiotherapists and rehabilitation specialists, particularly in high-prevalence, resource-conscious settings like Pakistan, these findings offer clear, evidence-based guidelines for clinical decision-making:

1. **Targeted Intervention Selection:** Clinicians should utilize neurodynamic assessments (e.g., ULNT1) and tissue palpation/elastography to guide treatment. Patients presenting with prominent radicular symptoms, nerve tension, or central sensitization should be prioritized for Bowen Therapy. Patients presenting with severe myofascial restriction, palpable fascial adhesions, and reduced tissue compliance will benefit most from SMR.
2. **Cost-Effective Self-Management:** Given the accessibility and low cost of foam rollers, SMR is an excellent prescription for home exercise programs, empowering students to manage their fascial stiffness independently.
3. **Combined Protocols:** In clinical practice, a combined approach may yield optimal results. Utilizing SMR to mechanically reduce fascial stiffness prior to BT to address neurodynamic restrictions could theoretically maximize both biomechanical and neuromodulatory benefits.

Limitations

While this study employed a rigorous stratified RCT design, certain limitations must be acknowledged. First, the follow-up period was limited to 4 weeks post-intervention; thus, the long-term retention of the biomechanical and neurodynamic changes remains unknown. Second, the sample was restricted to university students in Islamabad, which may limit the generalizability of the findings to older populations, different occupational groups, or those with chronic degenerative cervical pathologies. Finally, the study

evaluated the interventions in isolation; it did not assess the synergistic effects of combining BT and SMR in a single treatment protocol.

Future Recommendations

Future research should address these limitations by incorporating longitudinal follow-ups (6 to 12 months) to evaluate the sustained efficacy of both modalities. Additionally, subsequent studies should investigate combined treatment protocols to determine if a sequential application of SMR and BT yields superior clinical outcomes.

From an analytical perspective, future trials should incorporate advanced predictive modeling and Artificial Intelligence (AI) algorithms to identify specific demographic and clinical biomarkers that predict individual treatment responses. Expanding the demographic stratification to include broader age group frequency analyses and incorporating objective biomechanical markers, such as 3D motion capture for postural analysis, will further enhance the statistical and clinical robustness of TNS research. Finally, integrating environmental and ergonomic assessments into future study designs could help evaluate the role of workplace and university infrastructure in mitigating the recurrence of Text Neck Syndrome.

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