

COMPARATIVE EFFICACY OF NEURAL GLIDING VERSUS TENSIONING NEURODYNAMICS ON MEDIAN NERVE EXTENSIBILITY IN ASYMPTOMATIC FLOOR CLEANERS: A RANDOMIZED CONTROLLED TRIAL

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Abstract

Repetitive upper limb activities commonly encountered in occupational settings can predispose individuals to peripheral nerve dysfunctions. Among these, floor cleaners are particularly at risk due to constant wrist and hand usage, which can lead to early, asymptomatic median nerve alterations. The purpose of this study is to detect early neural alterations in asymptomatic floor cleaners using the Upper Limb Tension Test (ULTT) and to compare the effects of neural gliding and tensioning techniques on median nerve extensibility. A randomized controlled trial was conducted on 94 asymptomatic floor cleaners aged 25–40 years at SGT University's Physiotherapy OPD. Participants were randomly assigned to either a neural tensioning group or a neural gliding group (n = 47 per group). Each group received three supervised intervention sessions per week over four weeks. Outcome measures included elbow extension range of motion (ROM) during ULTT, grip and pinch strength, pain pressure threshold (PPT), and two-point discrimination (2PD). Both groups showed statistically significant improvements across all measured parameters post-intervention ($p < 0.05$). However, no significant differences were observed between the groups, indicating that both techniques yielded comparable outcomes. ULTT proves useful in identifying subclinical neural changes in individuals at occupational risk. Neural gliding and tensioning techniques were equally effective in enhancing median nerve extensibility, suggesting their suitability for preventive strategies in workplace physiotherapy.

Keywords: Median Nerve; Neural Gliding; Neural Tensioning; Neurodynamics; Upper Limb Tension Test

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Introduction

Under normal physiological conditions, nerves are subjected to various mechanical forces arising from different postures and movements (Topp & Boyd, 2006). Certain daily activities increase tension or compressive load on neural tissues, particularly when specific positions-whether work-related or not-are repeatedly assumed or held static for prolonged periods. Without sufficient recovery time, these repetitive or sustained stresses can lead to chronic nerve compression (Rempel *et al.*, 1999). Exposure to high-magnitude mechanical stresses may damage the myelin sheath structure, ultimately compromising axonal integrity by restricting blood flow and inducing ischemia (Topp & Boyd, 2006).

Musculoskeletal disorders linked to work are among the most prevalent health problems worldwide (Lei *et al.*, 2005; Chang *et al.*, 2012). Workers in manufacturing, construction, agriculture, transport, and other sectors frequently engage tools, machinery, and everyday equipment with their hands, placing them in awkward postures that involve overextension, forceful exertion, and repetitive motions over long durations. Such conditions precipitate muscle dysfunction, tingling, inflammation, and pain, potentially resulting in serious injury or disability (Kietrys *et al.*, 2015; Gustafsson *et al.*, 2017; Charles *et al.*, 2018). Floor mopping is classified as a moderately heavy task, characterized by repetitive, asymmetric upper-limb movements. As Chang *et al.* describe, the upper hand guides the mop while the lower hand drives it, exposing cleaners to continuous repetitive motions common to cleaning tasks like dusting, wiping, mopping, and sweeping (Woods & Buckle, 2005). These repetitive actions subject nerves to tensile strains-either longitudinal or transverse relative to the nerve's length-and to both static and dynamic compressive stresses (Inbaraj *et al.*, 2019; Mueller & Maluf, 2002). When chronic tensile force and direct compression co-occur, neural blood flow diminishes and axoplasmic transport may be altered, potentially producing hypersensitivity. This combination of compression, ischemia, and stress-mediated over-excitation is believed to cause low-level neural inflammation (Carroll *et al.*, 2000). Bekkelund *et al.* reported a higher incidence of median nerve dysfunction among floor cleaners (Bekkelund *et al.*, 2001).

Peripheral nerves that are injured or inflamed exhibit increased mechanosensitivity-a heightened response to mechanical loading-which provides a clinical basis for assessing minor peripheral nerve injuries and can be evaluated using the ULTT (Coppieters *et al.*, 2001). Early detection of elevated

mechanosensitivity permits prompt intervention through neural mobilization, a movement-based technique that integrates the nervous system's structural, biomechanical, and functional components (Coppieters *et al.*, 2001; Ellis & Hing, 2008). Neural mobilization employs two main approaches-sliding/gliding and tensioning-to restore normal neural mechanics and optimize function, despite differing in the longitudinal excursion and strain they impart (Coppieters and Butler, 2008; Ellis *et al.*, 2012; Gilbert *et al.*, 2014; Goyal *et al.*, 2016; Boudier-Rev  ret *et al.*, 2017). To date, no studies have compared the effects of these techniques in asymptomatic individuals. Accordingly, this study aims to identify early neural changes and to evaluate the comparative efficacy of neural gliding versus tensioning on median nerve extensibility in asymptomatic floor cleaners.

Methodology

Study Design

This research employed a single-blind, parallel-arm randomized controlled trial (RCT) design. It was carried out at the Physiotherapy Outpatient Department of SGT University, Gurugram, India, during the period from May 2025 to June 2025.

Participants

Sample size estimation was performed using G*Power software version 3.1.9.7, utilizing a two-tailed independent samples t-test to evaluate the difference between neural gliding and tensioning interventions. Grip strength was used as the outcome measure for calculating effect size ($d = 0.834$) derived from a previous study by Bihter Akinoglu *et al.* (2020). The alpha level was fixed at 0.05, and statistical power was set at 95% to reduce Type II error probability and improve the sensitivity in detecting intergroup variation. These parameters led to a calculated minimum required sample size of 78 participants. To account for potential attrition or incomplete responses, an additional 20% was added, bringing the total sample size to 94 participants. All participants provided written informed consent prior to inclusion in the study. The research adhered to the ethical standards set forth in the Declaration of Helsinki, including respect for individuals, their right to make informed decisions, and the protection of their health and rights. Ethical approval for the study was granted by the Institutional Ethical Committee of SGT University under registration

number SGTU/FPHY/2024/331. The study was registered with the Clinical Trial Registry-India (CTRI) under the number CTRI/2025/05/087407.

94 asymptomatic young floor cleaners aged between 25 and 40 years, each with a minimum of three years of professional cleaning experience and engaging in repetitive upper limb tasks for no less than 19 hours weekly, were enrolled. Individuals were excluded if they had a history of upper limb trauma or surgery, diagnosed neuropathy, or any systemic condition that could influence nerve integrity (e.g., diabetes mellitus or thyroid dysfunction). Eligible participants were randomly assigned into Group 1 or Group 2 using simple random sampling via the lottery method. Consequently, both groups had equal numbers of participants ($n = 47$) (Figure 1). Being a single-blind study, participants were blinded to the type of intervention they received and the same physiotherapist delivered the interventions and conducted outcome assessments. However, the investigator who enrolled the participants and generated the random allocation sequence was different from the one who randomly allocated the participants into the groups.

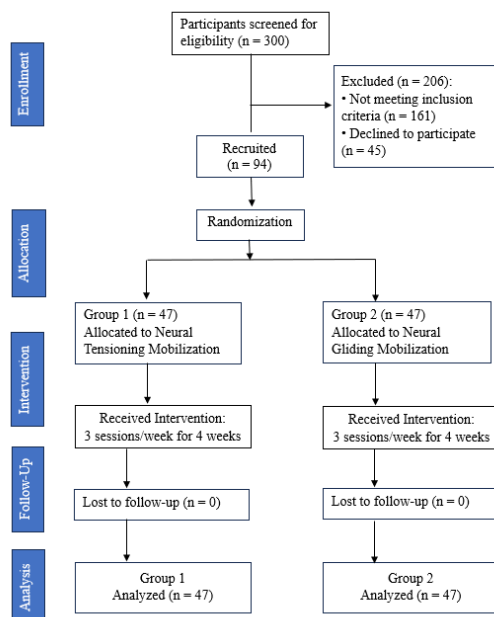


Figure 1. Consort flow chart of the participants

Detailed session logbooks were maintained for each participant throughout the study. These records documented attendance, the completion of prescribed sets and repetitions, and any relevant feedback or observations noted during the session. This systematic approach to tracking allowed monitoring of adherence closely, ensured

procedural consistency across all sessions, and maintained a reliable record of each participant's progress from baseline to the end of the intervention.

Evaluation

Participants were assessed at baseline, after the intervention. Measurements were taken for: ULTT, Elbow Extension ROM, Grip Strength, Pinch Strength, PPT and 2PD. All measurements were performed pre- and post-intervention and by the same physiotherapist to ensure consistency and eliminate inter-rater variability.

1. Sociodemographic data

Participants were asked to provide information regarding age, gender, dominant upper limb. Weight and height were also measured.

2. Elbow ROM

Elbow extension ROM was assessed using a standard universal goniometer during ULTT testing. To ensure accuracy, the patient was positioned appropriately, with the goniometric axis aligned with the medial epicondyle of the humerus. The stationary arm was positioned parallel to the longitudinal axis of the humerus, pointing toward the tip of the acromion, while the movable arm was aligned with the longitudinal axis of the forearm. This standardized method has demonstrated strong reliability, with intratester reliability ($r = .91$ to $.99$) and intertester reliability ($r = .88$ to $.97$) as reported by Rothstein *et al.* (1983).

3. Pinch Strength

Pinch strength was assessed using a mechanical pinch gauge (Saehan SH5005 pinch gauge), specifically targeting key pinch between the thumb and index finger. Participants were seated with the shoulder adducted and neutrally rotated, elbow flexed at 90° , forearm in a neutral position, and wrist positioned between 0° - 30° extension and 0° - 15° ulnar deviation and asked to pinch the pinch gauge as hard as they can. The pinch gauge has demonstrated excellent reliability ($ICC > 0.75$) for neurological conditions, and excellent ($ICC > 0.90$) for musculoskeletal disorders and healthy participants (Szekeres *et al.*, 2024).

4. Grip Strength

Grip strength was evaluated using a calibrated hand-held dynamometer (MicroFET). Participants were seated with the shoulder adducted and neutrally rotated, elbow flexed at 90° , forearm in a neutral position, and wrist positioned between 0° - 30° extension and 0° - 15° ulnar deviation. The dynamometer was consistently set to the second handle position for all subjects and asked to squeeze

the dynamometer. The instrument has demonstrated excellent intra-rater reliability (ICC = 0.974- 0.985) (Bohannon, 2006).

5. PPT

PPT was assessed using a handheld manual algometer, applied perpendicularly over the thenar and finger regions. Participants were seated with the shoulder adducted and neutrally rotated, elbow flexed at 90°, forearm supinated, and wrist in a neutral position. Pressure was applied at a rate of approximately 3 N/s and perpendicularly to the surface. Pressure was gradually increased until the subject reported the onset of pain. The interrater reliability of PPT measurement made using a pressure algometer was found to be very high (ICC = 0.91; 95% CI 0.82, 0.97) (Chesterton *et al.*, 2007).

6. 2PD

2PD was assessed using a standardized aesthesiometer (baseline aesthesiometer) applied to the thenar eminence and fingertip, with participants seated during testing. This method evaluates the minimal distance at which two stimuli were perceived as distinct. Static 2 PD inter-rater reliability at finger found to be 0.961 and moving 2PD inter-rater reliability was 0.922 at index finger (Dellon *et al.*, 1987).

Subject Screening

Out of 300 screened individuals, selection was conducted using the ULTT with median nerve bias, according to the protocol outlined by Butler and Jones (1991). This test involves sequential joint positioning that systematically increases mechanical stress on the nerve, enabling assessment of neural extensibility and sensitivity. Participants lay supine at the edge of the plinth, with the examiner in a stride stance. The shoulder girdle was initially depressed, then the glenohumeral joint abducted to

90-110°. Forearm supination, wrist and finger extension followed. External rotation of the shoulder was added, and finally the elbow was extended until a painless stretch was felt. At that point, elbow ROM was recorded using a universal goniometer. A difference of $\geq 10^\circ$ between limbs was considered diagnostic for median nerve tightness, in line with Van Hoof *et al.* (2012). Talebi *et al.* (2012) demonstrated high test-retest reliability for ULTT (ICC = $0.89 \pm 1.23^\circ$). Using this criterion, 94 participants were identified with subclinical tightness of the median nerve.

Intervention

Participants in Group 1 received median nerve tensioning mobilization based on the standardized ULTT position. Participants in Group 2 received neural gliding mobilization. Both groups underwent 3 sessions per week for 4 weeks.

Neural Tensioning Mobilization Technique

This intervention was applied on the dominant arm using ULTT-derived tensioning strategies, following protocols by Butler and Coppieters (2007, 2008). Subjects were positioned supine with the cervical spine in neutral. The physiotherapist maintained scapular depression and then carried out the standard ULTT sequence: shoulder abduction ($\sim 100-110^\circ$), forearm supination, wrist and finger extension, shoulder external rotation, and progressive elbow extension until a firm but painless end-feel was achieved. At this end-range, rhythmic oscillatory mobilizations were performed-starting with elbow extension held for 5-10 seconds, returning to mid-range, and then repeating the cycle. Each session consisted of 3 sets of 10 repetitions, paced at ~ 6 seconds per repetition, with 30 seconds rest between sets. The entire procedure was executed within the patient's comfort zone and without provoking symptoms (Figure 2).



Figure 2. Initial (left) and final (right) position for tensioning mobilization

Neural Gliding Mobilization Technique

The neural gliding protocol was administered with participants either seated or standing. The affected arm was placed in approximately 90° of shoulder abduction and elbow flexion, with the wrist in a neutral position. The glide-in phase involved elbow extension combined with ipsilateral neck side-bending, while the glide-out phase reversed the motion-elbow flexion with contralateral side-bending. These were carried out actively by the participant under supervision (Butler, 2000; Coppieters *et al.*, 2004; Shacklock, 2005). The intervention included 4 sets of 10 repetitions, each cycle lasting approximately 6 seconds, with 1-minute rest intervals between sets. The technique aimed to encourage neural excursion while avoiding excessive tensile load (Figure 3).

Data Analysis

All statistical procedures were performed using IBM SPSS Statistics, Version 27.0. Descriptive statistics for continuous variables were presented as mean $\pm$ standard deviation (SD). Gender, being a categorical variable, was described using percentages and analysed through the Chi-square test. To assess the distribution of each continuous outcome variable, the Kolmogorov-Smirnov test was applied. Since the results indicated a non-normal data distribution, non-parametric tests were employed. The Wilcoxon Signed-Rank Test was used for within-group comparisons (pre- and

post-intervention), while the Mann-Whitney U Test was employed to examine differences between the two groups. All statistical tests were performed at a 95% confidence interval, and a p-value of less than 0.05 was considered statistically significant.

Results and Discussion

Demographic Characteristics

All 94 participants recruited in this study completed the treatment sessions for 4 weeks. The data of all 94 participants [Group 1 (n = 47), Group 2 (n = 47)] were used for statistical analysis (Table 1).

Within-group analysis using the Wilcoxon Signed-Rank Test demonstrated statistically significant improvements in all parameters following the intervention in both groups ($p < 0.001$). These included elbow extension ROM, grip strength, pinch strength, pain pressure threshold (thenar and finger), and two-point discrimination (thenar and finger). However, between-group analysis using the Mann-Whitney U Test revealed no statistically significant differences in outcomes between Group 1 (tensioning) and Group 2 (gliding) ($p > 0.05$), as displayed in Table 2 and Figure 4. This indicates that both techniques had comparable effects on median nerve extensibility and sensorimotor function. Effect sizes were expressed as standardized mean differences (SMD; Cohen's d) with 95% confidence intervals, as shown in Table 2.



Figure 3. Initial (left) and final (right) position for gliding mobilization

Table 1. Demographic Characteristics

Variable	Group 1	Group 2	<i>t</i> value	<i>p</i> value
	Mean $\pm$ SD	Mean $\pm$ SD		
Age (years)	31.49 $\pm$ 5.38	30.32 $\pm$ 5.05	1.087	0.28
Gender ^a	M=23 (48.93%)	M=28 (59.57%)	1.072	0.301
	F=24 (51.06%)	F=19 (40.42%)		
Weight (Kg)	60.13 $\pm$ 9.40	59.56 $\pm$ 8.71	0.306	0.76
Height (cm)	161.16 $\pm$ 8.53	163.45 $\pm$ 6.80	1.442	0.153
BMI	23.32 $\pm$ 4.30	22.44 $\pm$ 4.20	0.994	0.323

M: Male; F: Female; BMI: Body Mass Index; ^achi-square test

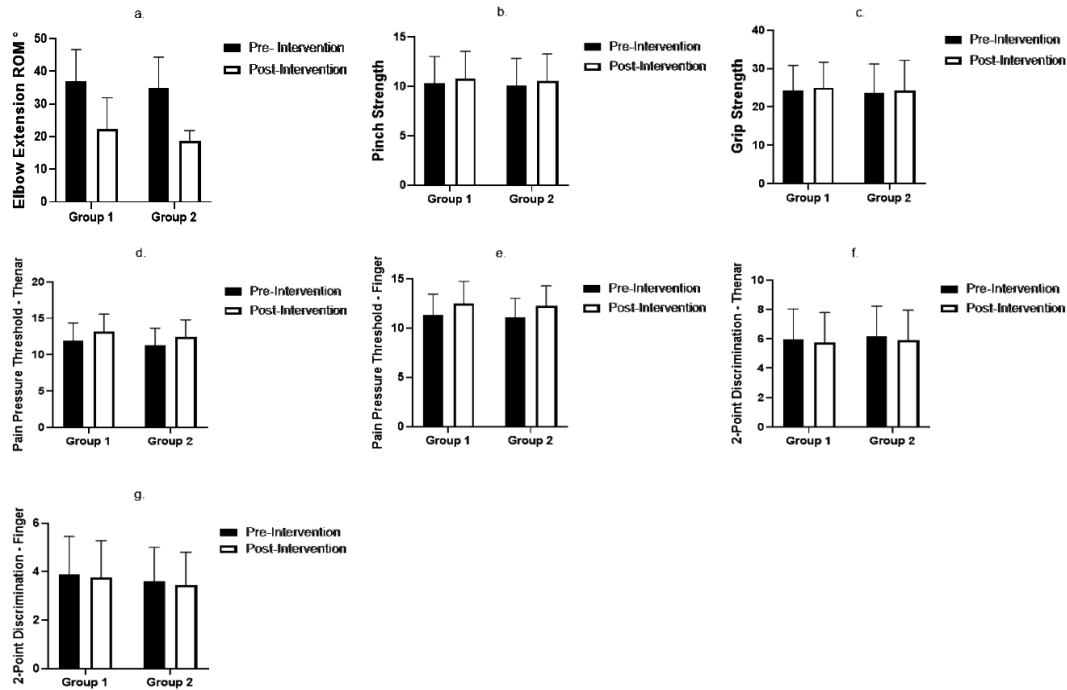


Figure 4. Mean $\pm$ SD of outcome variables for Group 1 and Group 2 before and after 4 weeks: (a) elbow extension ROM; (b) pinch strength; (c) grip strength; (d) pain pressure threshold (thenar); (e) pain pressure threshold (finger); (f) two-point discrimination (thenar); and (g) two-point discrimination (finger).

Table 2. Comparison of mean values of outcome variables within and between groups

Outcome Variable		Group 1	Group 2	<i>p</i> value	Effect Size (SMD; Cohen's <i>d</i> [95% CI])
		Mean $\pm$ SD	Mean $\pm$ SD		
Elbow Extension ROM (°)	Pre intervention	37.06 $\pm$ 9.64	35.00 $\pm$ 9.40	0.294	0.21 [-0.19, 0.62]
	Post intervention	22.36 $\pm$ 9.56	18.77 $\pm$ 9.11	0.071	0.38 [-0.03, 0.79]
	<i>p</i> value	<0.001*	<0.001*		
Pinch Strength (Kg)	Pre intervention	10.35 $\pm$ 2.71	10.12 $\pm$ 2.71	0.708	0.08 [-0.32, 0.49]
	Post intervention	10.80 $\pm$ 2.77	10.58 $\pm$ 2.73	0.697	0.08 [-0.33, 0.48]
	<i>p</i> value	<0.001*	<0.001*		
Grip Strength (Kg)	Pre intervention	24.32 $\pm$ 6.52	23.57 $\pm$ 7.60	0.578	0.11 [-0.30, 0.51]
	Post intervention	24.99 $\pm$ 6.68	24.29 $\pm$ 7.85	0.597	0.10 [-0.31, 0.50]
	<i>p</i> value	<0.001*	<0.001*		
PPT Thenar (Kgf)	Pre intervention	11.96 $\pm$ 2.39	11.33 $\pm$ 2.31	0.163	0.27 [-0.14, 0.67]
	Post intervention	13.12 $\pm$ 2.46	12.43 $\pm$ 2.34	0.212	0.29 [-0.12, 0.69]
	<i>p</i> value	<0.001*	<0.001*		
PPT Finger (Kgf)	Pre intervention	11.29 $\pm$ 2.17	11.07 $\pm$ 1.96	0.672	0.11 [-0.30, 0.51]
	Post intervention	12.50 $\pm$ 2.24	12.27 $\pm$ 2.03	0.688	0.11 [-0.30, 0.51]
	<i>p</i> value	<0.001*	<0.001*		
2PD Thenar (mm)	Pre intervention	5.96 $\pm$ 2.07	6.17 $\pm$ 2.06	0.633	-0.10 [-0.51, 0.30]
	Post intervention	5.73 $\pm$ 2.05	5.90 $\pm$ 2.05	0.69	-0.08 [-0.49, 0.32]
	<i>p</i> value	<0.001*	<0.001*		
2PD Finger (mm)	Pre intervention	3.89 $\pm$ 1.56	3.60 $\pm$ 1.40	0.375	0.19 [-0.21, 0.60]
	Post intervention	3.76 $\pm$ 1.52	3.44 $\pm$ 1.36	0.336	0.22 [-0.19, 0.63]
	<i>p</i> value	<0.001*	<0.001*		

ROM: range of motion; PPT: pressure pain threshold; 2PD: two-point discrimination; °: degree; kg: kilogram; kgf: kilogram-force; mm: millimeter; CI: confidence interval; SMD: standardized mean difference

Discussion

The purpose of the present study was to investigate early identification of neural changes and to compare the effects of two neural techniques, gliding and tensioning, both at pre-intervention and post-intervention. This randomized controlled trial confirmed the ULTT's diagnostic value for identifying early neural mechanosensitivity. Floor cleaners were selected based on evidence of their heightened risk for subclinical median nerve dysfunction due to repetitive upper-limb movements (Bekkelund *et al.*, 2001). The study also evaluated how neural tensioning versus gliding affected median nerve extensibility, pinch strength, grip strength, PPT, 2PD, and elbow ROM in asymptomatic floor cleaners.

Findings of this study suggests that 31.34% (94) of floor cleaners exhibited upper-limb neural hypersensitivity. Given the persistent wrist flexion, pronation, and gripping inherent to their duties, these workers face elevated neural strain. The ULTT not only measures ROM but also gauges mechanosensitivity, making it an invaluable screening tool for detecting dysfunction before symptoms emerge (Bialosky *et al.*, 2009). These findings align with Goyal *et al.*, who documented reduced neural extensibility in asymptomatic healthcare professionals. Talebi *et al.* reported high reliability of median-nerve ULTT in healthy subjects (ICC = 0.89). Similarly, Shahanawaz (2016) observed that prolonged poor posture in professional computer users led to altered neural tissue mobility. Together, these results underscore ULTT's role as a non-invasive, cost-effective occupational screening method that enables early ergonomic adjustments and preventive physiotherapy.

Current study compared the effects of two neural techniques, gliding and tensioning. Findings suggest that both techniques have similar and positive effects for neural tissue extensibility on elbow ROM, pinch strength, grip strength, PPT and 2PD in the mobilized limb. Both neural tensioning and gliding led to substantial gains in elbow extension range during ULTT after 4 weeks of intervention (39.7% to 46.3%). These improvements reflect reduced neural stiffness and fascial restriction, allowing greater nerve excursion and pain-free joint movement, and suggest that the median nerve became more compliant to elongation with diminished mechanosensitivity. Coppieters *et al.* (2003) demonstrated that enhancing neural mobility through targeted neurodynamic techniques can significantly increase elbow extension range prior to symptom onset during ULTT. In their trial, participants receiving median nerve mobilization exhibited a marked improvement in ULTT-related

elbow extension ROM accompanied by a reduction in pain levels in comparison to the control group. These findings suggest that neural gliding and tensioning interventions effectively reduce mechanosensitivity and restrictive neural tension, thereby allowing greater joint excursion without eliciting discomfort. This supports the therapeutic relevance of neurodynamic techniques in improving functional mobility and mitigating subclinical neural impairments. Though grip strength improved in both groups, they are unlikely to be clinically meaningful in healthy, asymptomatic workers and are better interpreted as signs of early neuromuscular adaptation and subclinical improvements before symptoms develop. This is consistent with previous research, where symptomatic cohorts (e.g., carpal tunnel syndrome, upper-quadrant pain) have shown larger and clinically meaningful gains in both strength and function following neurodynamic techniques (Ellis & Hing, 2008; Basson *et al.*, 2017; Paquette *et al.*, 2020). By contrast, in asymptomatic groups, smaller strength gains combined with larger improvements in neural mobility and mechanosensitivity outcomes highlight the preventive utility of neurodynamic interventions. Pinch strength improved significantly in both groups (4.35% to 4.54%). Ellis and Hing (2008) suggested that such changes may result from reduced inhibitory input and improved motor unit recruitment, while Salehi *et al.* (2020) noted that enhanced nerve excursion improves conduction and reduces pain-related inhibition, thereby supporting strength improvements. Both interventions showed comparable increases in PPT, ranging from 9.7% to 10.8%. This outcome is clinically meaningful, as it indicates reduced peripheral mechanosensitivity and greater tolerance to mechanical stress. Butler and Jones (1991) emphasized that improved intraneural vascularity and reduced nerve pressure can explain such improvements. Previous trials, including Coppieters *et al.* (2015), demonstrated that regular neurodynamic mobilization enhances pressure tolerance while minimizing overstress. These findings suggest that both tensioning and gliding effectively reduce subclinical hypersensitivity, supporting their relevance for preventive physiotherapy in high-risk occupational groups. 2PD improved in both groups, with gains of 3.86% to 4.44% in both groups. These changes highlight improved afferent signaling and potential cortical reorganization. Bayram *et al.* (2022) similarly demonstrated that median nerve mobilization enhanced 2PD acuity in healthy adults, supporting the notion that neurodynamic techniques can improve somatosensory processing even in asymptomatic individuals. These findings align with Butler and Jones (1991) principle that controlled

nerve elongation stimulates connective tissue remodeling and promotes interfascicular sliding.

This study reinforces the clinical relevance of early neurodynamic intervention in physiotherapy, particularly for individuals engaged in repetitive upper limb tasks such as floor cleaners, who are at elevated risk for subclinical neural dysfunctions. The ULTT proved effective as a non-invasive screening tool for detecting early neural mechanosensitivity, supporting its integration into occupational health assessments. Both neural gliding and tensioning techniques demonstrated therapeutic value in preserving nerve function, improving pressure-pain thresholds, and enhancing tactile discrimination. Gliding techniques, due to their lower mechanical strain, are especially suitable for early-stage or hypersensitive cases, while tensioning may be reserved for individuals requiring greater adaptability to mechanical stress. These findings advocate for routine neurodynamic screening and tailored mobilization protocols within workplace physiotherapy programs to prevent progression to neuropathic conditions such as carpal tunnel syndrome, ultimately promoting long-term musculoskeletal health and functional resilience in high-risk occupational populations.

Limitations

This study has few limitations. A control group was not included in the present study; however, this limitation will be addressed in future research. Recruitment was restricted to a single site, which, although sufficient for the study's objectives, may limit the generalizability of the findings. Future research will consider multicentre design to improve external validity. Follow-up assessments were not performed. The study focused exclusively on asymptomatic young floor cleaners, which restricts applicability to symptomatic populations or other occupational groups.

Conclusion

This research demonstrates that both neural tensioning and gliding effectively enhance median nerve flexibility, muscular strength, and sensory performance in asymptomatic floor cleaners. Utilizing ULTT for early neural screening highlights neurodynamic techniques' role not only in rehabilitation but also in proactive care within high-risk work environments. By adopting ULTT as a routine assessment tool and integrating regular neural mobilization protocols, occupational physiotherapy can take a significant step forward in safeguarding nerve health among at-risk professionals.

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References

- Akinoglu, B., Ünüvar, E., Kocahan, T., & Hasanoğlu, A. (2020). The acute effect of nerve-gliding exercises on the handgrip strength of adolescent tennis players. *Türkiye Klinikleri Journal of Sports Sciences*, 12(3), 267-273. <https://doi.org/10.5336/sportsci.2020-73978>
- Basson, A., Olivier, B., Ellis, R., Coppieters, M., Stewart, A., & Mudzi, W. (2017). The effectiveness of neural mobilization for neuromusculoskeletal conditions: A systematic review and meta-analysis. *Journal of Orthopaedic & Sports Physical Therapy*, 47(9), 593-615. <https://doi.org/10.2519/jospt.2017.7117>
- Bayram, G. A., Ciddi, P. K., & Marangoz, C. (2022). The effect of median nerve mobilization on two point discrimination. *Journal of Physical Therapy Science*, 34(6), 422-425. <https://doi.org/10.1589/jpts.34.422>
- Bekkelund, S. I., Torborgsen, T., Rom, A. K., & Mellgren, S. I. (2001). Increased risk of median nerve dysfunction in floor cleaners: A controlled clinical and neurophysiological study. *Scandinavian Journal of Plastic and Reconstructive Surgery and Hand Surgery*, 35(3), 317-321. <https://doi.org/10.1080/028443101750523258>
- Bialosky, J. E., Bishop, M. D., Price, D. D., Robinson, M. E., & George, S. Z. (2009). The mechanisms of manual therapy in the treatment of musculoskeletal pain: A comprehensive model. *Manual Therapy*, 14(5), 531-538. <https://doi.org/10.1016/j.math.2008.09.001>
- Bohannon, R. W. (2006). Test-retest reliability of the MicroFET 4 hand-grip dynamometer. *Physiotherapy Theory and Practice*, 22(4), 219-221. <https://doi.org/10.1080/09593980600822875>
- Boudier-Révérét, M., Gilbert, K. K., Allégue, D. R., Moussadyk, M., Brismée, J. M., Sizer, P. S., & Sobczak, S. (2017). Effect of neurodynamic mobilization on fluid dispersion in the median nerve at the level of the carpal tunnel: A cadaveric study. *Musculoskeletal Science and Practice*, 31, 45-51. <https://doi.org/10.1016/j.msksp.2017.07.004>
- Butler, D. S. (2000). *The sensitive nervous system*. Noigroup Publications.
- Butler, D. S., & Coppieters, M. W. (2007). Neurodynamics in a broader perspective. *Manual Therapy*, 12(1), e7-e8. <https://doi.org/10.1016/j.math.2007.01.001>
- Butler, D. S., & Jones, M. A. (1991). *Mobilisation of the nervous system*. Churchill Livingstone.
- Carroll, L. J., Côté, P., Cassidy, J. D., & Kristman, V. (2000). The factors associated with neck pain and its related disability in the Saskatchewan population. *Spine*, 25(9), 1109-1117. <https://doi.org/10.1097/00007632-200005010-00012>
- Chang, J.-H., Wu, J.-D., Liu, C.-Y., & Hsu, D.-J. (2012). Prevalence of musculoskeletal disorders and ergonomic assessments of cleaners. *American Journal of Industrial Medicine*, 55(7), 593-604. <https://doi.org/10.1002/ajim.22064>
- Charles, L. E., Ma, C. C., Burchfiel, C. M., & Dong, R. G. (2018). Vibration and ergonomic exposures associated with musculoskeletal disorders of the shoulder and neck. *Safety and Health at Work*, 9(2), 125-132. <https://doi.org/10.1016/j.shaw.2017.10.003>

- Chesterton, L. S., Sim, J., Wright, C. C., & Foster, N. E. (2007). Interrater reliability of algometry in measuring pressure pain thresholds in healthy humans using multiple raters. *The Clinical Journal of Pain*, 23(9), 760-766. <https://doi.org/10.1097/AJP.0b013e318154b6ae>
- Coppieters, M. W., & Butler, D. S. (2008). Do “sliders” slide and “tensioners” tension? An analysis of neurodynamic techniques and considerations regarding their application. *Manual Therapy*, 13(3), 213-221. <https://doi.org/10.1016/j.math.2006.12.008>
- Coppieters, M. W., Andersen, L. S., Johansen, R., Giskegjerde, P. K., Hoivik, M., Vestre, S., & Nee, R. J. (2015). Excursion of the sciatic nerve during nerve mobilization exercises: An in vivo cross-sectional study using dynamic ultrasound imaging. *Journal of Orthopaedic & Sports Physical Therapy*, 45(10), 731-737. <https://doi.org/10.2519/jospt.2015.5833>
- Coppieters, M. W., Bartholomeeusen, K. E., & Stappaerts, K. H. (2004). Incorporating nerve-gliding techniques in the conservative treatment of cubital tunnel syndrome. *Journal of Manipulative and Physiological Therapeutics*, 27(9), 560-568. <https://doi.org/10.1016/j.jmpt.2004.10.006>
- Coppieters, M. W., Stappaerts, K. H., Everaert, D. G., & Staes, F. F. (2001). Addition of test components during neurodynamic testing: Effect on range of motion and sensory responses. *Journal of Orthopaedic & Sports Physical Therapy*, 31(5), 226-237. <https://doi.org/10.2519/jospt.2001.31.5.226>
- Coppieters, M. W., Stappaerts, K. H., Wouters, L. L., & Janssens, K. (2003). The immediate effects of a cervical lateral glide treatment technique in patients with neurogenic cervicobrachial pain. *Journal of Orthopaedic & Sports Physical Therapy*, 33(7), 369-378. <https://doi.org/10.2519/jospt.2003.33.7.369>
- Dellon, A. L., Mackinnon, S. E., & Crosby, P. M. (1987). Reliability of two-point discrimination measurements. *The Journal of Hand Surgery*, 12(5), 693-696. [https://doi.org/10.1016/s0363-5023\(87\)80049-7](https://doi.org/10.1016/s0363-5023(87)80049-7)
- Ellis, R. F., & Hing, W. A. (2008). Neural mobilization: A systematic review of randomized controlled trials with an analysis of therapeutic efficacy. *Journal of Manual & Manipulative Therapy*, 16(1), 8-22. <https://doi.org/10.1179/106698108790818594>
- Ellis, R. F., Hing, W. A., & McNair, P. J. (2012). Comparison of longitudinal sciatic nerve movement with different mobilization exercises: An in vivo study utilizing ultrasound imaging. *Journal of Orthopaedic & Sports Physical Therapy*, 42(8), 667-675. <https://doi.org/10.2519/jospt.2012.3854>
- Gilbert, K. K., Roger James, C., Apte, G., Brown, C., Sizer, P. S., Brismée, J. M., & Smith, M. P. (2014). Effects of simulated neural mobilization on fluid movement in cadaveric peripheral nerve sections: Implications for the treatment of neuropathic pain and dysfunction. *Journal of Manual & Manipulative Therapy*, 23(4), 219-225. <https://doi.org/10.1179/2042618614Y.0000000094>
- Goyal, M., Mehta, S. K., Rana, N., Singal, R., Mittal, A., Goyal, K. S., Sharma, S., Chatterjee, S., & Sharma, M. (2016). Motor nerve conduction velocity and function in carpal tunnel syndrome following neural mobilization: A randomized clinical trial. *International Journal of Health & Allied Sciences*, 5(2), 104-110. <https://doi.org/10.4103/2278-344X.180434>
- Gustafsson, E., Thomée, S., Grimby-Ekman, A., & Hagberg, M. (2017). Texting on mobile phones and musculoskeletal disorders in young adults: A five-year cohort study. *Applied Ergonomics*, 58, 208-214. <https://doi.org/10.1016/j.apergo.2016.06.012>
- Inbaraj, L., Mohan, V., George, C., & Norman, G. (2019). Prevalence of complaints of arm, neck, and shoulders among computer professionals in Bangalore: A cross-sectional study. *Journal of Family Medicine and Primary Care*, 8(1), 171. https://doi.org/10.4103/jfmpe.jfmpe_253_18
- Kietrys, D. M., Gerg, M. J., Dropkin, J., & Gold, J. E. (2015). Mobile input device type, texting style, and screen size influence upper extremity and trapezius muscle activity and cervical posture while texting. *Applied Ergonomics*, 50, 98-104. <https://doi.org/10.1016/j.apergo.2015.03.003>
- Lei, L., Dempsey, P. G., Xu, J., Ge, L., & Liang, Y. (2005). Risk factors for the prevalence of musculoskeletal disorders among Chinese foundry workers. *International Journal of Industrial Ergonomics*, 35(3), 197-204. <https://doi.org/10.1016/j.ergon.2004.08.007>
- Mueller, M., & Maluf, K. (2002). Tissue adaptation to physical stress: A proposed physical stress theory to guide physical therapist practice, education, and research. *Physical Therapy*, 82(4), 383-403. <https://doi.org/10.1093/ptj/82.4.383>
- Paquette, P., Higgins, J., & Gagnon, D. H. (2020). Peripheral and central adaptations after a median nerve neuromobilization program completed by individuals with carpal tunnel syndrome: An exploratory mechanistic study using musculoskeletal ultrasound imaging and transcranial magnetic stimulation. *Journal of Manipulative and Physiological Therapeutics*, 43(6), 566-578. <https://doi.org/10.1016/j.jmpt.2019.10.007>
- Rempel, D., Dahlin, L., & Lundborg, G. (1999). Pathophysiology of nerve compression syndromes: Response of peripheral nerves to loading. *The Journal of Bone and Joint Surgery*, 81(11), 1600-1610. <https://doi.org/10.2106/00004623-199911000-00013>
- Rothstein, J. M., Miller, P. J., & Roettger, R. F. (1983). Goniometric reliability in a clinical setting. *Physical Therapy*, 63(10), 1611-1615. <https://doi.org/10.1093/ptj/63.10.1611>
- Salehi, S., Hesami, O., Poursaeed Esfehiani, M., Khosravi, S., Rashed, A., Haghighatzadeh, M., Hassabi, M., & Abedi Yekta, A. H. (2020). The effectiveness of exercise therapy and dry needling on wrist range of motion, pinch, and grip force in carpal tunnel syndrome: A randomized clinical trial. *Asian Journal of Sports Medicine*, 10(4). <https://doi.org/10.5812/asjms.83927>
- Shacklock, M. (2005). *Clinical neurodynamics: A new system of neuromusculoskeletal treatment*. Elsevier Health Sciences.
- Shahanawaz, S. (2016). Upper limb neural tissue extensibility in apparently asymptomatic professional computer users. *ARC Journal of Neuroscience*, 1(2). <https://doi.org/10.20431/2456-057X.0102003>
- Szekeres, M., Aspinall, D., Kulick, J., Sajid, A., Dabbagh, A., & MacDermid, J. (2024). Reliability, validity, and responsiveness of pinch strength assessment: A systematic review. *Disability and Rehabilitation*, 1-13. <https://doi.org/10.1080/09638288.2024.2382907>
- Talebi, G. A., Oskouei, A. E., & Shakori, S. K. (2012). Reliability of upper limb tension test 1 in normal subjects and patients with carpal tunnel syndrome. *Journal of Back and Musculoskeletal Rehabilitation*, 25(3), 209-214. <https://doi.org/10.3233/bmr-2012-0330>
- Topp, K. S., & Boyd, B. S. (2006). Structure and biomechanics of peripheral nerves: Nerve responses to physical stresses and implications for physical therapist practice. *Physical Therapy*, 86(1), 92-109. <https://doi.org/10.1093/ptj/86.1.92>
- Van Hoof, T., Vangestel, C., Shacklock, M., Kerckaert, I., & D'Herde, K. (2012). Asymmetry of the ULNT1 elbow extension range-of-motion in a healthy population: Consequences for clinical practice and research. *Physical Therapy in Sport*, 13(3), 141-149. <https://doi.org/10.1016/j.pts.2011.09.003>
- Woods, V., & Buckle, P. (2005). An investigation into the design and use of workplace cleaning equipment. *International Journal of Industrial Ergonomics*, 35(3), 247-266. <https://doi.org/10.1016/j.ergon.2004.09.004>