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Effect of Thai Yoga Exercise for Reducing Pain and Improve Functional Disability in Patients with Text Neck Syndrome: A Randomized Controlled Trial

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Abstract

Text neck syndrome (TNS) is prevalent among mobile users, and exercise is a simple, non-invasive approach, for treating chronic neck pain. Research on Thai yoga (TY) exercise to relieve or reduce neck and shoulder pain in people with TNS is still limited. This study aimed to investigate the effects of TY exercise on health, physical function and quality of life in patients with TNS. A randomized clinical trial was conducted from April to July 2023 (TCTR20230920002, 10/2023). Seventy-eight volunteers with TNS participated in the study, performing TY exercises, while continuing their routine daily life (CON) for 6 weeks, with week 8 as a follow-up appointment. Clinical evaluation was conducted using a numerical pain-rating scale, functional disability scored by the neck disability index questionnaire (NDI), range of motion (ROM) and cervical vertebral angle, rounded shoulder angle by goniometry, and health-related quality of life (QoL) assessed by the 36-Item Short Form Survey. The results of the numerical pain-rating scale for TY group in the follow-up (6.71±0.52 weeks) were significantly different (p-value < 0.001) from the baseline (4.18±0.95) while the CON group showed no change. The NDI also decreased from the baseline (5.03±1.38) in the TY group, while the CON group remained at 12.03±1.98. The data of craniovertebral angle of TY group show an increase from baseline (62.44±2.32) while CON group was 39.37±4.73. The results showed that the rounded shoulder angle of TY group decreased to the normal range. The TY group shows an increased degree from baseline. The results for the TY group demonstrated a significant increase in QoL. These findings suggest that TY exercise is effective for relieving TNS when compared with the CON group. These positive outcomes provide strong support for the use of TY as an effective intervention for treating TNS symptoms.

Keywords**:** *Thai Yoga; text neck syndrome; neck pain; range of motion*

1. Introduction

Text neck syndrome (TNS) refers to recurring stress injury caused by overuse of smartphones when users are bending over their devices or maintaining a forward position for too long (Vijayakumar et al., 2018). TNS patients often experience neck pain, limited cervical movement, reduced muscle strength and endurance, altered cervical joint position, and postural alterations (Shinde, & Bhende, 2023). The risk factors for TNS include gestures, duration, frequency and characteristics of smartphone use (Aroeira et al., 2017). According to recent studies, the

prevalence of musculoskeletal complaints among mobile device users ranges from 1.0% to 67.8% and neck complaints have the highest prevalence rates ranging from 17.3% to 67.8% (Xie et al., 2017). A recent study reported that undergraduate students spend approximately 9 hours a day on their electronic devices (Kutty, 2019). The excessive use of hand-held smartphones leads to common causes of musculoskeletal disorder (MSD) in the neck area (Hajihosseini et al., 2016). A previous study reported that people who had experienced chronic pain showed a lower health-related quality of life (QoL) (Rapti et al., 2019). Moreover, it is recommended that patients who suffer from neck and shoulder pain with damage to the trapezius muscle should perform nonpharmacological exercise-based therapy (Taimela et al., 2000). In particular, it is advisable to perform self-exercise as a practical method to manage TNS (Sarraf et al., 2023).

Exercise provides substantial health advantages comparable to pharmaceuticals. Similar to administering any medication, it's essential to maintain appropriate dosage to prevent adverse effects. The positive effects of exercise extend to the general population, aiding in the prevention of various illnesses and promoting longevity (Vina et al., 2012). Thai Yoga (TY) also known as Rusie Datton is a traditional Thai exercise invented by Thai hermits with the aim of relieving muscle pain caused by prolonged hours of meditation practice (Widjaja et al., 2021). The fundamental principles and techniques of TY closely resemble those of the hatha style, with both being identified as forms of low-intensity exercise. TY exercises have demonstrated significant benefits, particularly in improving overall body flexibility and enhancing flexibility in the right shoulder joint (Kongkaew et al., 2018). TY exercise integrates a gentle range of motion (ROM), deep breathing, and breath-holding. Previous studies have confirmed the positive effects of TY exercise on improved QoL, including muscle and joint flexibility (Kongkaew et al., 2018; Ngowsiri et al., 2016). In another study on the effects of TY exercise on office syndrome, results showed that TY exercise reduced neck pain and increased ROM (Thanasilungkoon et al., 2022).

A review of the literature found that TY exercises can reduce pain levels while promoting physical flexibility. Flexibility exercises seem to promote muscle flexibility leading to better fitness and physical performance. TNS patients can perform these body & mind exercises by themselves. Three TY exercises designed for the neck include a stomachache and headache posture, a chest and body discomfort posture, and a hand and foot weakness posture. However, current research on TY exercise to relieve or reduce neck and shoulder pain in people with TNS is still limited. Therefore, this study aimed to investigate the effectiveness of TY exercise on pain levels, neck deformity, ROM, and QoL in patients with TNS, before and after the intervention. This research hypothesis was that these outcomes would improve after TY exercises when compared to the CON groups.

2. Objectives

1. The study examined the effects before and after TY exercise on pain levels, neck disability, range of motion, and quality of life in patients with TNS.

2. The study compared the effects of TY exercise on pain levels, neck disability, range of motion, and quality of life between the TY and CON groups.

3. Materials and Methods

3.1 Participants

The sample size was calculated using G* Power version 3.1.9.4. The effect size was determined from the variance of the pain level in a previous study with a similar research design equal to 0.70 and the level of statistical significance was equal to 0.05. The power of the test was set to 0.95 (Seemal et al., 2022) and 10% of the sample was added to compensate for the expected dropout. Therefore, there were 44 participants in each group. Figure 1 shows the study flowchart. This study was conducted at the Thai Traditional Medicine Clinic, Faculty of Nursing and Health Sciences, from April to July 2023.

Inclusion Criteria

1. Patients aged 18–35 who had suffered from text neck syndrome for at least 3 months

2. Experienced neck pain that worsened with prolonged posture and a feeling of stiffness when turning the head and neck after extended use

3. History of having used smartphones for more than 2 hours per day

4. Craniovertebral angle lower than 50º and rounded shoulder angle lower than 52º (Seemal et al., 2022)

5. Had a pain level of at least 5 on a visual analog scale (Seemal et al., 2022)

6. Had neck disability index score of at least 10 (Seemal et al., 2022)

7. Commitment to participate for the duration of the study

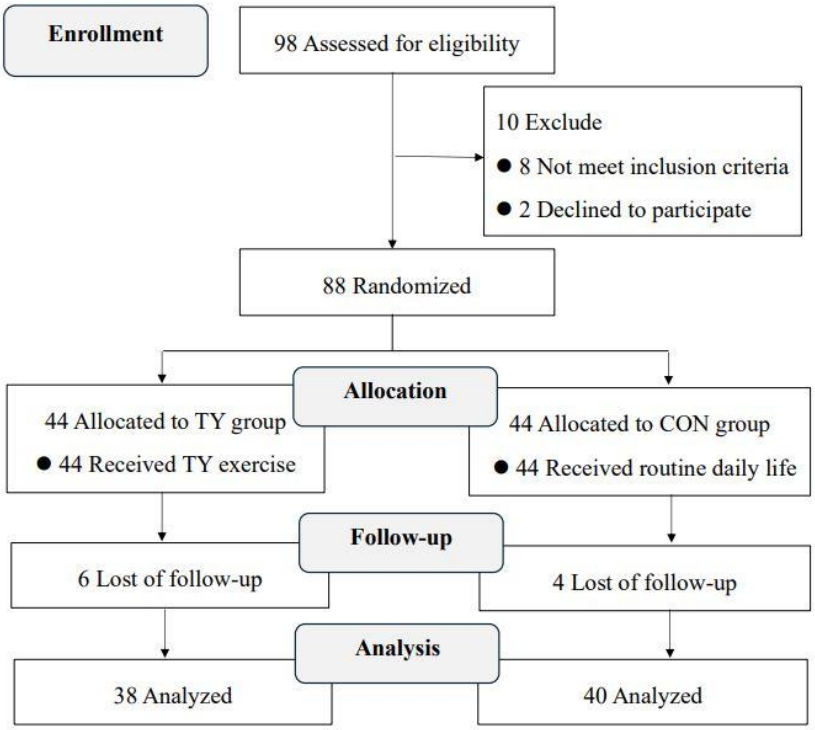

Figure 1 Flowchart of study

Exclusion Criteria

1. Females who were pregnant or breastfeeding
2. Received acupuncture treatment or physiotherapy during the study
3. Used or applied steroid medication within 2 weeks before participating in the study
4. Patients with any spinal infection or inflammatory disorder, neck surgery, trauma, torticollis, scoliosis, malignancy, diagnosed cases of disc prolapse, stenosis, herniation, spondylolisthesis, osteoporosis (Seemal et al., 2022)

The study was announced to the public to recruit volunteers who were willing to participate in the study. An appointment was made with each volunteer to conduct a pain assessment and physical examination according to the inclusion and exclusion criteria. Eighty-eight volunteers who met all the inclusion criteria were randomly divided into two groups (TY group and CON group, who did not perform the TY exercise).

3.2 Randomization and Blinding

Participants were recruited using a randomized complete block design method based on age and the level of neck pain. A single-blind method was employed for blinding because of the research process used. The participants knew which group they belonged to, whereas the researchers were blind to which group the participants were randomly allocated to. In addition, the group number was not specified in the data record.

3.3 Procedure

This study was approved by the Human Research Ethics Committee of Phetchaburi Rajabhat University, it was conducted in accordance with the Helsinki Declaration no. 6/2023 and registered with the Thai Clinical Trials Registry (TCTR20230920002). Informed consent was obtained from all the participants before they participated in this study. The TY group performed three postures taught by the researchers. The first assessment at baseline was conducted before the demonstration of the TY exercise.

Participants were directed to perform TY exercises for 45 minutes, 15 minutes for each posture, 3 times a week, for a duration of 6 weeks. TY group learned and practiced three exercise postures taught by the researchers at the Thai Traditional Medicine Clinic. In particular, three postures are designed for neck exercises. First, the stomachache and headache posture (Figure 2.A) aims to relieve abdominal pain,

ankle pain and headache. It is the posture to exercise the head, shoulders, chest, arms and stomach to stimulate blood circulation to the head. Second, a chest and body discomfort and hand posture (Figure 2.B) aims to cure blurry vision and to relieve physical discomfort all over the body. This posture exercises the neck, chest and legs. Third, a hand and foot weakness posture (Figure 2.C) aims to relieve tired hands and feet. This posture exercises the neck, waist and knees (MoPH, 2013). After the participants were evaluated and confirmed to perform the TY postures correctly. Participants were given a guidebook on TY postures, a document outlining their home exercise schedule and record of adverse symptoms following exercise, with designated exercise days being Monday, Wednesday, and Friday.

The CON group did not perform the TY postures and continued their routine daily life. Participants in the CON group had to sit on a chair on Tuesday, Thursday, Saturday for 45 minutes, three times a week, for a duration of 6 weeks.

The researchers made follow-up phone calls (3 minutes) three times in week 1, week 3 and week 5 to ask the participants about the date, the schedule and the recording of performing the TY postures and the problems found during the intervention program.

The researchers scheduled each group of volunteers on different days to prevent them from meeting and interacting with each other. The researchers made five appointments with each participant in week 0 (baseline), week 2, week 4, week 6 and week 8 as a follow-up. In every appointment, the researchers assessed the outcomes in the form of pain intensity, neck disability index (NDI) and ROM in week 0, week 2, week 4, week 6 and week 8, whereas QoL, as measured by the 36-Item Short Form Survey (SF-36), was measured in week 0 and week 6.

3.4 Outcome Measurement

The tool's content validity was assessed by three specialists, including a physiotherapist, a traditional Thai medicine doctor, and an applied Thai medicine doctor.

3.4.1 Pain Intensity

A numerical rating scale (NRS) from 0 to 10 is a reliable measure used in clinical studies conducted on chronic pain treatments (Cleeland, & Ryan, 1994). In this study, NRS was rated from 0 to 10, where 0 was no pain, 1–5 was mild, 6–7 was moderate and 8–10 was severe (Boonstra et al., 2016).

3.4.2 Neck Disability Index

The NDI is considered as the most widely used self-report measurement of the level of neck pain in current clinical studies (Resnick, 2005). The Thai version of the assessment form (Thai NDI) consists of 10 questions, each of which had six options with a score interpretation of 0–4 (no disability), 5–14 (slight disability), 15–24 (moderate disability), 25–34 (severe disability) and 35–50 (complete disability) (Kittiwarawut, & Amnuaypornsathit, 2014). The Thai version of NDI is a valid and reliable measurement method for evaluating neck pain disability (Luksanapruksa et al., 2012).

Figure 2 TY postures: stomachache and headache (A), chest and body discomfort (B), and hand and foot weakness (C). The photo was taken by researchers, and the person in this photo signed the informed consent to publish in this study

3.4.3 Craniovertebral, Rounded Shoulder Angle and Range of Motion

In this study, A manual goniometer was used to measure the craniovertebral angle (CVA), rounded shoulder angle (RSA) and ROM. Goniometer has been chosen as a valid, reliable, simple and widely used tool to evaluate active cervical ROM (Macwan, & Radadiya, 2023). The CVA can be assessed by measuring the angle between the line connecting the C7 spinous process with the tragus of the ear and the horizontal line. A CVA greater than 50° was viewed as normal but a CVA lower than 50° was viewed as abnormal (Selvaganapathy et al., 2017). RSA is constructed by the horizontal line in the middle of the humerus and the line from the midpoint of the humerus to the spinous process of C7. A 2022 study suggested ≤52° as the reference angle (Guduru et al., 2022). Measures of posture and ROM were found to reflect neck pain and disability, and joint ROM is a significant measure to assess disability (Engelberg, 1988). The ROM was measured in pairs, in six positions: flexion, extension, right-side bending, left-side bending, right rotation and left rotation. The validity and reliability measure of cervical range of motion and found that it was a valid and reliable (Audette et al., 2010). The Index of item objective congruence (IOC) was assessed on CVA, RSA and ROM with IOC value equal to 1.

3.4.4 Health Survey

The SF-36 is a tool to measure the QoL in patients with neck pain suffering from smartphone use and this was translated into Thai (Leurmamkul, & Meetam, 2000) to measure health status. It consists of 36 questions divided into eight health dimensions, including general health (GH), physical function (PF), social function (SF), role-physical (RP), role-emotional (RE), bodily pain (BP), vitality (VT) and mental health (MH). The reported health transition questions were scored on a scale of 0 (worst) to 100 (optimal health). The participants were asked to complete the survey on their QoL twice before the study and again in week 6. The content validity index was assessed of a SF-36 with a CVI of 1. The SF-36 has undergone testing and validation, confirming its reliability and validity (Audette et al., 2010).

3.5 Statistical Analyses

Data were analyzed using IBM SPSS Statistics version 24.0 (IBM Co., Armonk, NY, USA). Descriptive statistics of frequency, percentage, mean and standard deviation (SD) were used to analyze the results of both groups. Qualitative data were presented as proportions, and the Chi-square test was used to test for significance. Within-group comparisons using quantitative data employed paired t-tests, while independent sample t-tests were used to compare between the two groups. A Two-Way Mixed ANOVA compares the difference between multiple sets that include between-groups and repeated-measures variables. A p-value < 0.05 was considered statistically significant.

4. Results

4.1 General Characteristics of All Participants

In the TY group, 6 participants were lost to follow-up. Of these, 2 experienced severe shoulder pain and used topical medication, 2 were unable to attend their scheduled appointments, and 2 engaged in intensive exercise in preparation for a sports competition. In the CON group, 4 volunteers were lost to follow-up. Of these, 3 did not attend their scheduled appointments, and 1 received treatment with massage. Seventy-eight participants in both groups suffered from neck pain caused by TNS. The majority of participants in both groups were female. The demographic characteristics of all the participants in both groups were similar. On average, participants in both groups were in their early 20s. The body mass index (BMI) values in both groups were within the normal range. The participants included a range of occupations, such as undergraduate students, government officials, and company employees. There was no difference in shoulder pain patterns. As for pain periods, all participants in both groups experienced the same periods. (Table 1). According to feedback from participants and the assessment of adverse symptoms, no negative symptoms were observed in the TY group.

4.2 Pain Intensity

At baseline, there had been no significant difference in pain scores between the 2 groups. The NRS score in the TY group had decreased from 6.71±0.52, indicating moderate pain, to 4.18±0.95, indicating mild pain, from baseline to follow-up. The change in score for the TY group from baseline to follow-up week had been 2.52±1.13, showing a statistically significant reduction in pain score ($p<0.001$). Meanwhile, the pain level in the CON group had remained stable, from 6.70±0.69 to 6.48±0.68, still indicating mild pain from baseline to follow-up. The change in score for the CON group had been 0.22±0.89, remaining significantly unchanged ($p=0.394$) (Table 2).

4.3 Craniovertebral, Rounded Shoulder Angle and Range of Motion

A goniometer was used to assess the craniovertebral angle, rounded shoulder angle, and range of motion. The cervical angle of each participant was measured at every follow-up session. Craniovertebral angle values were detailed in Table 2. At baseline, there was no significant difference in CVA between the two groups. The CVA value in the TY group increased from 40.50±5.54, indicating an abnormal level, to 62.44±2.32, indicating a normal level, from baseline to follow-up. The change in score for the TY group from baseline to follow-up week was 22.31±7.11, showing a statistically significant increase in CVA value ($p<0.001$). In contrast, the CVA value in the CON group remained stable, from 40.20±4.21 to 39.37±4.73, still indicating an abnormal level from baseline to follow-up. The change in CVA value for the CON group was 0.82±6.21, remaining significantly unchanged ($p=0.739$).

At baseline, there was no significant difference in RSA between the two groups. The RSA value in the TY group decreased from 62.65±3.69, indicating an abnormal level, to 56.44±5.51, indicating a normal level, from baseline to follow-up. The change in RSA score for the TY group from baseline to follow-up week was 6.21±6.49, showing a statistically significant decrease in RSA value ($p=0.001$). While, the RSA value in the CON group remained stable, from 62.05±2.81 to 62.70±2.88, still indicating an abnormal level from baseline to follow-up. The change in RSA value for the CON group was 0.65±4.56, remaining significantly unchanged ($p=0.340$) (Table 2).

The ROM was evaluated in pairs across six positions, with the ROM values presented in Table 3. The ROM value in the TY group showed a statistically significant increase ($p<0.001$). The measurement positions with the change of score in TY group, in order, were right rotation, left-side bending, neck flexion, neck extension, right-side bending, and left rotation, respectively. Meanwhile, the ROM value in the CON group remained unchanged. The measures of right-side bending and right rotation in the TY group also significantly increased compared to the CON group ($p<0.001$) (week 2 to follow-up). The measures of flexion, extension, left-side bending and left rotation in the TY group had significantly greater ROM compared to that in the CON group ($p<0.001$) (from week 4 to follow-up).

4.4 Health Survey

Table 4 showed results on SF-36 parameter between groups, found that the seven domains in TY group including physical function (PF), role-physical (RP), role-emotional (RE), bodily pain (BP), social function (SF), vitality (VT) and mental health (MH) increased statistically significantly ($p<0.001$ and $p=0.05$), while only RP domain within the CON group increased significantly ($p=0.008$). Nevertheless, the general health in both groups was similar.

Table 1 Baseline clinical characteristics of participant

Characteristics	TY group (n=38)	CON group (n=40)	p value
Sex (n, %)			0.821[a]
- Female	33 (86.8)	4 (85)	
- Male	5 (13.2)	6 (15)	
Age (year)	20.79±2.39	20.8±2.04	0.748[b]
Weight (mean±SD)	57.37±9.96	57±10.06	0.945[b]
BMI (mean±SD)	22.30±3.17	22.17±3.45	0.547[b]
Sex (n, %)			0.821[a]
- Female	33 (86.8)	4 (85)	
- Male	5 (13.2)	6 (15)	
Occupation (n, %)			0.993 [a]
- Undergraduate students	30 (78.9)	32 (80.0)	
- Government officials	5 (13.2)	5 (12.5)	
- Company employees	3 (7.9)	3 (7.5)	
Shoulder pain patterns (n, %)			0.516 [a]
- Both sides	24 (63.2)	26 (65.0)	
- Right	9 (23.7)	6 (15.0)	
- Left	5 (13.2)	8 (20.0)	
Pain period (months) (mean±SD)	5.13±1.74	5.16±1.59	0.884 [b]

[a]p value calculated by a chi-squared test.
[b]p value calculated by an independent samples *t*-test.

Table 2 Numerical rating scale (NRS), neck disability index (NDI), craniovertebral angle (CVA) and rounded shoulder angle (RSA) parameters within and between groups, measured at baseline, week 2, week 4, week 6, and follow-up

Measure	Baseline (mean±SD)	Week2 (mean±SD)	Week4 (mean±SD)	Week6 (mean±SD)	Follow-up (mean±SD)	[a]*p*-value	Change of score[c] (mean±SD)
NRS							
TY group	6.71±0.52	5.82±0.56	4.21±0.84	3.92±0.91	4.18±0.95	<0.001**	2.52±1.13
CON group	6.70±0.69	6.58±0.71	6.65±0.62	6.65±0.58	6.48±0.68	0.394	0.22±0.89
[b]*p*-value	0.939	<0.001**	<0.001**	<0.001**	<0.001**		<0.001**
NDI							
TY group	12.28±1.83	10.76±1.38	8.26±1.37	4.68±1.21	5.03±1.38	<0.001**	7.26±2.29
CON group	12.00±2.18	11.65±2.19	11.68±1.98	11.90±1.96	12.03±1.98	0.508	0.025±2.38
[b]*p*-value	0.529	0.037*	<0.001**	<0.001**	<0.001**		<0.001**
CVA							
TY group	40.50±5.54	45.68±7.44	53.59±2.88	62.57±2.00	62.44±2.32	0.001*	22.31±7.11
CON group	40.20±4.21	39.65±4.65	40.35±4.78	39.82±4.14	39.37±4.73	0.739	0.82±6.21
[b]*p*-value	0.954	<0.001**	<0.001**	<0.001**	<0.001**		<0.001**
RSA							
TY group	62.65±3.69	56.57±2.90	53.71±2.63	52.26±1.48	56.44±5.51	0.001*	6.21±6.49
CON group	62.05±2.81	62.97±2.56	61.95±4.11	63.00±2.17	62.70±2.88	0.340	0.65±4.56
[b]*p*-value	0.415	<0.001**	<0.001**	<0.001**	<0.001**		<0.001**

[a]*p*-value is calculated by repeated measure ANOVA test to determine differences within groups in different periods.
[b]*p*-value is calculated by ANOVA for comparison between groups.
[C]Change of score between baseline and follow-up
*$p<0.05$,**$p<0.001$: statistically significant differences.

Table 3 Range of motion parameters within and between groups cut off at baseline, week 2, week 4, week 6 and follow-up

Measure	Baseline (mean±SD)	Week 2 (mean±SD)	Week 4 (mean±SD)	Week 6 (mean±SD)	Follow-up (mean±SD)	[a]p value	Change of score[c] (mean±SD)
Flexion							
TY group	31.79±6.16	37.26±7.03	42.61±8.19	50.92±9.78	44.18±9.11	<0.001**	12.39±6.66
CON group	32.13±8.69	32.25±11.53	32.30±11.89	32.00±11.31	32.93±9.89	0.841	0.8±8.97
[b]p value	0.845	0.024	<0.001**	<0.001**	<0.001**		<0.001**
Extension							
TY group	36.66±11.25	40.61±10.53	45.92±10.23	51.89±9.94	47.47±10.00	<0.001**	10.81±5.35
CON group	37.15±7.23	36.80±8.47	35.43±8.83	36.08±11.50	36.13±9.91	0.376	1.02±8.76
[b]p value	0.818	0.082	<0.001**	<0.001**	<0.001**		<0.001**
Right-side bending							
TY group	37.58±8.89	43.84±9.29	48.26±8.90	51.82±9.71	47.97±8.49	<0.001**	10.39±10.11
CON group	36.88±6.99	37.53±7.25	37.60±6.77	37.80±6.05	37.43±5.32	0.719	0.55±5.71
[b]p value	0.698	0.001*	<0.001**	<0.001**	<0.001**		<0.001**
Left-side bending							
TY group	41.50±9.69	44.18±9.18	51.63±8.99	58.50±8.49	54.21±8.64	<0.001**	12.71±11.31
CON group	42.03±9.44	41.98±8.161	41.73±6.25	40.93±7.48	41.88±6.72	0.439	0.15±5.98
[b]p value	0.809	0.264	<0.001**	<0.001**	<0.001**		<0.001**

Table 3 Cont.

Measure	Baseline (mean±SD)	Week 2 (mean±SD)	Week 4 (mean±SD)	Week 6 (mean±SD)	Follow-up (mean±SD)	[a]p value	Change of score[c] (mean±SD)
Right rotation							
TY group	51.87±6.91	57.42±6.15	65.03±6.21	74.03±8.91	66.34±7.01	<0.001*	14.47±8.54
CON group	52.75±7.52	52.38±6.44	52.55±5.99	52.90±7.56	52.28±7.30	0.887	0.47±6.93
[b]p value	0.592	0.001*	<0.001**	<0.001**	<0.001**		<0.001**
Left rotation							
TY group	49.45±9.43	54.26±8.95	58.32±7.86	64.08±8.06	57.71±7.04	<0.001**	8.26±8.74
CON group	48.88±9.72	49.78±9.87	49.98±10.72	49.58±10.23	49.10±9.25	0.524	0.22±5.38
[b]p value	0.793	0.039*	<0.001**	<0.001**	<0.001**		<0.001**

[a]*p*-value is calculated by repeated measure ANOVA test to determine differences within groups in different periods.
[b]*p*-value is calculated by ANOVA for comparison between group.
[C]Change of score between baseline and follow-up
*$p<0.05$,**$p<0.001$: statistically significant differences.

Table 4 SF-36 parameters cut off at baseline, week 6 between groups

SF-36 Domains	Baseline (mean±SD)	Week 6 (mean±SD)	[a]*p*-value
General Health (GH)			
TY group	59.74±13.45	67.89±17.73	0.003*
CON group	64.88±18.86	65.88±16.52	0.526
[b]*p*-value	0.169	0.604	
Physical Function (PF)			
TY group	79.87±15.22	89.21±14.02	0.004*
CON group	71.75±13.71	73.50±15.33	0.090
[b]*p*-value	0.015*	<0.001**	
Social Function (SF)			
TY group	63.16±11.59	75.26±13.50	<0.001**
CON group	65.50±14.88	65.63±15.66	0.897
[b]*p*-value	0.442	0.005*	
Role-physical (RP)			
TY group	46.24±18.53	68.95±10.41	<0.001*
CON group	52.25±13.82	54.75±14.85	0.008*
[b]*p*-value	0.107	<0.001*	
Role-emotional (RE)			
TY group	63.55±13.30	75.53±12.18	<0.001**
CON group	62.00±12.03	62.25±14.09	0.809
[b]*p*-value	0.590	<0.001**	
Bodily Pain (BP)			
TY group	47.63±11.25	61.58±10.21	<0.001**
CON group	52.63±10.74	52.00±11.42	0.594
[b]*p*-value	0.49	<0.001**	
Vitality (VT)			
TY group	58.82±12.05	68.03±11.60	0.002*
CON group	58.75±18.21	57.50±19.35	0.086
[b]*p*-value	0.985	0.005*	
Mental Health (MH)			
TY group	59.84±12.24	72.16±16.72	<0.001*
CON group	60.38±17.19	62.25±20.28	0.079
[b]*p*-value	0.875	0.022*	

[a]*p*-value is calculated by paired t test for within-group comparison
[b]*p*-value is calculated by independent sample t-test for between-group comparison
*$p<0.05$ and **$p<0.001$: statistically significant differences.

5. Discussion

The study evaluated the effects of TY exercise on pain levels, neck disability, range of motion, and quality of life in patients with TNS. Additionally, it compared these effects between the TY group and the CON group. To recapitulate, the NRS scores revealed that all participants reported a decrease in muscle pain after two weeks of TY exercise, which persisted

through the follow-up period. However, only the TY group exhibited a significant decrease in pain level compared to baseline, while the CON group did not show any reduction in pain. When explored further, TY exercise incorporates breathing control together with stretching (Khanthong et al., 2022). The stretching of muscles and joints transmits signals that interfere with the transmissions of nociceptive fibers, which helps inhibit the pain depending on the individual's perception of pain. Gate control theory explains that a neurological gate within the dorsal horn is activated by painful stimuli. If non-painful stimuli override the painful stimuli, the gate will remain closed and the person will not feel pain (Nirvanie-Persaud et al., 2022). Current research confirmed that stretching releases endogenous opioids as pain-reduction substances released in the human body (Wei, 2023).

Our results showed that TY exercise changed the NDI level from mild to no disability, while the CON group could not change the NDI level. The researchers explained that the NDI can be relieved by neck exercises that help correct, strengthen and stretch deep flexor muscles. The neck exercises should also aim to strengthen the shoulder girdle muscles, such as the scapulothoracic muscle, to promote the proper position of the upper spine so that it can maintain accurate head and neck posture (Sarraf et al., 2023). Several studies have recommended that neck disability can be improved by exercise among patients with chronic neck pain (Philadelphia Panel Members et al., 2001). These results were similar to those of another study on yoga (Michalsen et al., 2012) and Tai Chi (Lauche et al., 2016).

The CVA in the TY group was still in the normal range (>50°) because the shortening of the scalenus muscles in the neck region can lead to changes in CVA, which induce restricted ROM in neck extension. The results in this study were consistent with the findings of a previous study that validated that craniocervical flexor training (Oh, & Yoo, 2016) and yoga (Michalsen et al., 2012) improved CVA in patients with chronic neck pain. The results in the TY group showed a decrease in RSA to the normal range (52°) because the stretching exercise improved the scapular stabilizers and straightened the pectoralis minor, leading to greater round shoulder posture (Ruivo et al., 2016). In addition, the TY group had a greater ROM because any type of stretching is an effective approach to increase ROM (Thomas et al., 2018). A greater ROM is associated with pain tolerance, muscle–tendon viscoelastic properties (Ferreira et al., 2007) and a larger number of sarcomeres in series (Coutinho et al., 2004). Previous study reported that an increase in ROM was observed after TY exercise (Suksai et al., 2019; Thanasilungkoon et al., 2023). While the CON group could not increase CVA, RSA and ROM. Previous studies show that yoga can reduce neck pain severity, enhance pain tolerance, and increase range of motion (Singh et al., 2020). In this study, subjects performed TY exercises for 45 minutes three times a week for a period of 6 weeks. The result showed that TY group had higher ROM in left flexion, extension, and rotation compared to the CON group from week 4 until follow-up. Previous research indicates that yoga training enhanced body flexibility by 3.94 cm (week 4) and 8.93 cm (week 8) compared to regular activities (Tran et al., 2001). TY group showed an increased ROM in right flexion and rotation compared to CON group from week 2 to follow-up. This is consistent with past studies that have found practicing Thai yoga improves body flexibility of the body and the right shoulder joint (Kongkaew et al., 2018). In addition, a previous study found that in an experimental group that exercised 3 times a week, 45 minutes each time, the results showed significant differences in neck pain reform exercise, shoulder joint range of motion, and neck range of motion compared to the control group (Tabatabaei et al., 2017). Exercising 3 times a week for 45 minutes each time is related to improved health-related quality of life in individuals with musculoskeletal pain (Amiri, 2022). The QoL results reported that the TY group had significantly higher scores in seven domains because stretching helped relieve MSD-related pain by enhancing a greater ROM and better blood circulation in the painful muscles (Lawand et al., 2015). Furthermore, yoga postures were found to help lower both cortisol levels and depression by causing changes in brainwave activities. A previous study indicated that weekly yoga exercises promoted alpha waves as a brainwave of relaxation while these exercises lowered cortisol levels (Kamei et al., 2000). The findings related to the quality of life in this study were in agreement with previous report (Singthong et al., 2021).

The advantage of assessing pain intensity and neck ability using self-assessed questionnaires in both groups was noted. The limitation of this evaluation was that the TY group might have felt there should have been less pain and neck disability after the TY exercises, whereas the CON group showed no change in these outcome variables. The assessment of CVA, RSA, and ROM using a goniometer indicated that TY

exercises led to an increase in the CVA angle, normalization of RSA, and an overall improvement in ROM. A weakness of this method was the increase in the angle and ROM due to muscle movement from repeated measurements. The QoL study using the SF-36 questionnaire found that the baseline RP scores had not been different between the two groups. However, when they were measured again at week 6, both the TY group and the CON group showed a statistically significant increase in RP. When comparing between groups at week 6, the RP score of the TY group had increased significantly more than that of the CON group. The increase in RP in both groups might have resulted from the participants not having had issues with work or daily activities. Our SF-36 (RP) results were consistent with those described by Boonruab et al., (2018), where the self-rated physical scores of qualities of life contrasted with objectively measurable outcome variables such as pain intensity and ROM.

There were some limitations to this study. First, there was no screening of other medical history such as headaches, subjective vertigo or results of ophthalmologist examination. Second, we did not conduct laboratory tests such as substance P or cortisol. Further investigation through a larger study is necessary to validate these findings.

6. Conclusion

In summary, there is clinical evidence suggesting that TY exercise which three postures can reduce pain and decrease neck disability, while also increasing ROM and improving QoL in undergraduate students with text neck pain. Clinicians are encouraged to integrate a three-time per weekly regimen of forty-five minutes of TY exercises focusing on the shoulder and neck regions to relieve discomfort and improve overall well-being. To the best of our knowledge, this study is the first randomized controlled trial on the efficacy of TY exercise on patients with TNS. The results of this study are expected to be beneficial in the health promotion offered by existing knowledge of TY exercise according to traditional Thai medical wisdom.

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