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**Original Article**

# A Blinded, Controlled Study of the Effectiveness of Neck Movement, Positional Self-Release, and Mindful Breathing Performed During Computer Use

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**Running title:** Integrative technique & mindful breathing during computer-based work

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**Abstract**

**Objective:** Prolonged computer use may lead to musculoskeletal disorders and stress. A new rehabilitative method has therefore been developed for promoting both mental and physical health in the workplace, involving neck movement, positional self-release (PSR), and deep, slow mindful breathing (DSB). The therapeutic regimen can be performed intermittently as appropriate during long periods of computer use.

**Material and Methods:** Thirty participants aged 20-25 years were recruited and, after examination by a blinded assessor, randomized into three groups, namely the positional release technique (PRT) group, exercise group (EX), and control group (CN). Participants in all three groups performed ninety minutes of simulated computer use, then exercise (IG and CG groups) or rest (CG group) for 20 minutes. In the case of exercise, this was repeated four times in each position over two minutes on each side of the body, until all five postures had been completed.

**Results:** Neck tension and neck pain were significantly reduced, and cervical range of motion (CROM) was increased post-intervention in the PRT and EX groups. Furthermore, the parasympathetic dominance of heart rate variability (HRV) in the PRT group was significantly increased.

**Conclusion:** The benefit of taking breaks from computer use and performing exercise has been demonstrated. Furthermore, there is added value in synchronizing PRT with the rhythm of increasing neck mobility while reducing pain and tension.

**Keywords:** deep slow breathing (DSB), heart rate variability (HRV), mind-body therapy, positional release technique (PRT), work quality.

## Introduction

Computers are a necessary office tool,[1] allowing users to access online media by means of which business can be conducted more efficiently and effectively. Nevertheless, sedentary computer work can cause neck tension, which may result in the development of non-specific neck pain. More generally, prolonged computer use may lead to the emergence of musculoskeletal

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disorders, including stress [2] and negative emotions, which may all amplify the pain[3] experienced by office workers. [4]

The positional release technique (PRT) is one of the most commonly used physiotherapeutic methods. It is a passive and indirect technique by means of which the physiotherapist positions the affected part of the body in a comfortable position by means of movements that are guided by the palpation of tender points that are found at a small depth below the skin. Performing PRT evokes physiological changes in the musculoskeletal system, whereby hypertonicity and fascial tension are normalized by positioning the muscles in a way that optimizes relaxation. [5]

Conversely, conventional neck exercises are an active technique performed by the subject and one of the easiest and most applicable methods to reduce tension and improve mobility[6]; a wide range of exercise types have been proposed. [7,8] A previous study performed in this laboratory revealed that just a few minutes of incorporating four occasions of repeated slow stretching in synchronization with deep, slow breathing (DSB), and with the eyes closed, promoted relaxation and reduced muscle tension,[9] demonstrating that including DSB as part of a mind-body therapy promoted increases in parasympathetic tone and tolerance of pain.[10-13] The self-awareness elicited during the movement and breathing cycle is known as "mindfulness," and it is recommended for reducing negative emotions, or muddled thoughts, in a person who may not have experience with meditation.[14-17] The associated improvement in mental health leads to a person feeling more valued at work, leading to positive personal and job-related outcomes.[18-19]

For the past decade, recommendations for health promotion and disease prevention have mostly focused on the enhancement of wellness and holistic adjustment, while the main aim presently is to develop a new integrated exercise program suitable for office workers, supporting their wellbeing whilst using computers over a prolonged period of time. Accordingly, in the three groups of participants, the efficacy of a new rehabilitative therapy combining self-administered PRT with DSB has been compared with conventional exercise and also a control condition, for reducing muscle tension, reducing pain score, increasing CROM, and heart rate variability (HRV) alteration, following a simulated period of prolonged computer use.

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## Materials and Methods

### Study Design and Setting

The study was approved by the Research Ethics Committee (RRE) of Khon Kaen University (KKU), registered with the Clinical Trials Registry (Ref: *****), and carried out in a quiet laboratory room kept at a constant temperature of 25 ° C.

### Participants

Thirty healthy female participants were recruited, aged between 20 and 25 years. Inclusion criteria were normal body mass index (BMI) and working on a computer for a minimum of 4 hours daily. Potential participants who exhibited any signs of neurological, psychological, or musculoskeletal disorders, including systemic diseases (e.g., fibromyalgia and rheumatoid arthritis), and those experiencing neck pain or a pain perception intensity above 3/10 (i.e., moderate to severe pain) were excluded. The sample size was calculated based on the expected extravasation rate of 2.0% with 80% power.

### Procedures

All eligible participants were randomly assigned to one of three groups, namely the positional release technique (PRT) group, the exercise group (EX), and the control group (CN). All participants were provided with a description of the study, and members of the PRT and EX groups separately learnt and practiced the skills necessary to perform the relevant intervention by viewing video clips and obtaining guidance from one of two research assistants until they performed the task correctly. Next, all participants performed a simulated computer use task for 90 minutes, followed by 20 minutes of intervention, namely, self-administered PRT by the PRT group, neck exercises by the EX group, and static stretching by the CN group (Figure 1). Participants in the PRT and EX groups performed the relevant tasks in the upright sitting position, focusing on the neck muscles frequently affected by non-specific neck pain.[19-21]

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**Figure 1.** Flowchart of the study protocol and the data collection steps.

The PRT group performed integrated dynamic muscle stretching synchronized with deep slow breathing (DSB). The eyes were closed, and a synchronised deep inhalation was performed during stretching; eyes were opened, and a slow exhalation was performed during subsequent release. The cycle of stretch and release was repeated step by step for each side. The whole procedure was repeated twice. [9-19]

The EX group repeated a static stretching task in which the neck muscles on one side were stretched for 30 seconds with the eyes open, with a rest interval of five seconds between stretches, and then repeated on the opposite side. The whole procedure was then repeated a second time. This group was not instructed to perform DSB synchronized with the stretching. [8]

The CN group simply rested in a comfortable sitting position for 20 minutes after the ninety minutes of simulated computer use.

**Outcome Measures**

An assessor who had more than 10 years' experience in physiotherapy, and who was blinded to the group to which they had been assigned, examined participants prior to commencement of the experiment. All outcome measures were recorded at baseline, immediately after the computer simulation task, and again at the end of the experiment. The four outcome measures were muscle tension score, pain intensity, heart rate variability (HRV), and cervical range of motion CROM), as detailed below.

Muscle tension score and pain intensity were the primary outcome measures. They were recorded using a visual analog scale (VAS), comprising a ten-centimeter (cm) horizontal line shown to be highly reliable for recording subjective measures (ICC=0.97).[22] To measure muscle tension, participants were asked to rate the intensity of the tension in their neck muscles within a range of 0 (no tension) to 10 cm (the most tension imaginable); to measure neck pain, participants were asked to rate the level of pain that they were presently experiencing in the neck and shoulders within a range of 0 (no pain) to 10 cm (the most pain imaginable).

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Heart Rate Variability (HRV) was a secondary outcome measure and recorded as a means of assessing the autonomic nervous system via changes in the R-R interval of cardiac waveforms.[23] The measure was recorded using a BIOPAC MP 100 System (BIOPAC Inc., Santa Barbara, California, USA) with an Ag-Ag surface electrode (TSD 150B) set to a gain of 350 and positioned on cleaned skin at the site of the lead II reference line of the electrocardiogram (ECG). The domains of low frequency (LF), high frequency (HF), and low frequency per high frequency ratio (LF/HF ratio) were selected for analysis using a band-pass filter of between 1 and 35 Hz. Spectral powers were set at three frequency bands, namely total power (0 to 0.40 Hz), LF power (0.04 to 0.15 H), and HF power (0.15 to 0.40 Hz).[24] Participants were requested to rest quietly in a comfortable sitting position during the five minutes it took to record the measurements. The raw HRV data were analysed using AcqKnowledge software version 4.2, written for the Biopac system.

Cervical range of motion (CROM) was an additional secondary outcome measure and recorded using a CROM Goniometer (Performance Attainment Associates, Roseville, MN, USA), which has been shown to provide highly consistent repeat measurements.[25] The participant was seated upright, and the yoke was placed on their shoulders, with the arrow on the dial pointing vertically. The inclinometers were then placed on the participant's head, and neck movements in six directions corresponding to flexion/extension, left/right lateral flexion, and left/right rotation were automatically determined by a magnet on the inclinometer, causing the arrow in the yoke to deflect. Repeat measurements obtained by the same assessor were found to be highly consistent, with ICC between 0.88 and 0.95.

**Data Analysis**

All variables were summarised and presented as mean and standard deviation (SD) for each group at each time point using the SPSS computer program for Windows (version 17.0, Chicago, IL), and the assumptions of normal distribution and homogeneity of variance were confirmed via the Shapiro-Wilk test and Levene test, respectively. Analysis of variance (ANOVA) was used to test the homogeneity of the scores at baseline, and paired t-tests and Wilcoxon signed-rank tests were used to analyse mean differences within each group before and after the intervention.

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Repeated measures ANOVA and Kruskal-Wallis tests were used to test for significant differences in the effect of the intervention between groups and were followed by post hoc Student-Newman-Keuls (SNK) pairwise comparisons to determine the nature of potential differences. The significance level was set to $p<0.05$.

## Results

The values of the outcome measures obtained for the three groups of participants are shown in Table 1; as shown in Table 2, there were no significant differences between the three groups at baseline for any of the outcome measures ($p>0.05$).

### *Neck muscle tension and pain*

The participants in all three groups experienced an increase in neck tension and neck muscle pain following the 90 minutes of computer use, which were significantly reduced post-intervention in all three groups. The greatest reduction in muscle tension scores was in the PRT group ($p<0.005$), whereas the CN group showed the greatest reduction in pain intensity ($p<0.01$). However, the differences in change in muscle tension and change in pain intensity between the groups were not significantly different ($p=0.16$ and $p=0.81$, respectively).

### *Heart rate variability*

It is difficult to identify the particular findings that have been obtained. The HRV analysis provided three scores. 1) Regarding the measurement of HRV at LF, this increased in the PRT and CN groups, whereas it decreased in the EX group post-intervention. The measurement of HRV at LF increased in the PRT and CN groups ($p=0.03$ and $p=0.20$, respectively) and decreased in the EX group ($p=0.17$) post-intervention. 2) The measurement of HRV at HF increased in the CN group ($p=0.06$) and decreased in the PRT and EX groups post-intervention. However, the changes in HRV measured at LF and HF were not significantly different between the PRT and EX groups.

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Lastly, the LF/HF HRV ratio significantly increased after simulated computer use in all three groups, and decreased after intervention in both the PRT ($p<0.05$) and EX groups ($p<0.03$). There were significant differences in the change in the LF/HF ratio between the groups ($p=0.01$). However, the post-hoc test did not reveal any alterations in the interaction between the groups.

***Neck movement***

The measurements of CROM were significantly reduced following the period of simulated computer use in all three groups, and it was the PRT group that showed the greatest recovery in mobility following the intervention, followed by the EX group, especially for lateral flexion and leftward rotation ($p=0.03$ and $p=0.01$, respectively), but not for rotation to the right. For the CN group, there was no significant change in the CROM measures following the rest period. The differences between groups were significant in lateral flexion and rotation to the left ($p<0.01$ for each), where there was a difference between the PRT and EX groups ($p<0.05$), and between the PRT and CN groups ($p<0.01$), as well as for lateral neck flexion to the left, where there was an interaction between the PRT and CN groups ($p<0.01$) and between the EX and CN groups: CG vs CO ($p<0.01$).

## Discussion

Computer use, especially for extended periods of time, can cause musculoskeletal discomfort, especially neck tension and pain, which can progress to limitations in neck function. The results of the present study show that using a computer for longer than an hour causes heightened neck discomfort and reduced mobility. The PRT protocol, incorporating DSB, produced the greatest decrease in neck tension and, interestingly, resting in a comfortable sitting position post-computer use produced the greatest decrease in pain.

In previous studies, it has been shown that taking breaks at work, without any specific intervention, can be effective in reducing neck and upper-back muscle discomfort[26]. Furthermore,

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a recent systematic review found that breaks with postural changes influenced pain reduction and the feelings of discomfort in the lower back in computer workers, although the effect sizes were insufficient to confirm the recommendation.[27] Interestingly, in a recent study, it was observed that the lengths of breaks taken by most office workers are less than ten minutes, and only 4.2% of respondents performed light exercises and stretching, which may be insufficient to reduce tension and pain.[28] Based on the findings of the present study, a break time of at least 20 minutes, seated in a comfortable position, is recommended to reduce neck pain.

Performing PRT required synchronization between muscle stretching and release, and the cycle of deep, slow breathing. It is possible that the synchronized rhythm between stretching and breathing is a significant factor and related to proprioceptive feedback between the stretched muscle fibers and muscle-spindle excitability.[29] Increased flexibility occurred in the EX group, who performed a static stretching exercise, as well as in the control (CN) group, albeit not as great as in the PRT group. In the case of the EX group, activation of the stretch reflex may have reduced the excitability of the muscles by inhibiting the mechanoreceptors or the muscle neuron pools associated with the compliance of muscle tendon units.[30,31] However, each period of PRT exercise required synchronous concentration on the muscle stretching and deep, slow breathing; unfamiliarity with concentrating on these elements may promote psychological stress, which may heighten pain sensitivity.[32] Obtaining increased familiarity with the protocol is likely to significantly extend the benefits that it produces.

The LF/HF HRV ratio is a measure of the balance between the sympathetic (fight-or-flight) and parasympathetic (rest-and-digest) nervous systems,[33] and one of the findings of the present study is that sympathetic activity, and thus feelings of fight-or-flight, was increased after the computer task. Participants reported that neck muscle tension and pain intensity decreased once they had stopped using the computer and performed exercises or rested. Interestingly, the significant reduction in the LF/HF ratio showed that the PRT protocol was especially effective in reducing sympathetic dominance, which was probably fostered by the beneficial effects of closing the eyes and performing DSB at a rate of around 5-6 breaths per minute, which has been reported to improve lung function after a period of 10 minutes.[34] The short-term beneficial effects of DSB have also been reported in terms of provoking the parasympathetic and baroreflex sensitivity

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(BRS) of the heart and lowering blood pressure,[35] improving lung function,[36] and controlling stress.[10,37] Self-protection mechanisms are activated by reducing parasympathetic tone in the heart through feedback from the vagal nerve to the brain, in accordance with energy restoration, to prepare for activity initiation. Emotions are also adjusted based on mindful meditative enhancement.[38] The PRT protocol may promote these effects and provide advantages in terms of increased self-awareness of personal conditions. To obtain maximum benefit, it is important that the skills necessary to effectively perform this self-treatment are learnt in a relaxed, stress-free setting.

The present study has several limitations that should be acknowledged. Firstly, only young, adult female participants were recruited. Although previous studies have shown that female office workers are at higher risk of developing non-specific neck pain, of course, male office workers are also affected.[39,40] In future studies, the range of ages of the participants should be increased and male participants recruited. Secondly, the entire study was carried out under noise-free, temperature-controlled conditions, and on only one occasion, and these conditions might not have prompted participants to perform the task as per their usual working conditions. Nevertheless, the time period that was set for the computer simulation task was of a sufficient duration to heighten neck pain. Thirdly, as discussed, the PRT intervention may be even more effective if it can be learnt over a longer period of time so that the office worker does not have any stress or anxiety regarding its correct implementation. Fourthly, there were some limitations regarding the assessment tools used to record the outcome measures, particularly the devices used for recording HRV, which also meant that pressure pain threshold was not recorded. Finally, in any future research, the long-term effects of computer use should be studied.

## Conclusion

The innovative self-administered PRT exercise protocol, synchronized with DSB, produced the most significant effects in reducing neck muscle tension and neck pain and increasing neck mobility, making it appropriate to potentially be incorporated during breaks from computer use in order to reduce neck discomfort and promote relaxation in office workers.

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**Authorship contribution statement**

Kyawt Ngon Phu was responsible for conceptualization, methodology, investigation, writing – original draft, data curation, validation.

Orawan Buranruk was responsible for supervision, conceptualization, methodology, investigation, writing – original draft, data curation, validation, review and editing. Neil Roberts was responsible for review and editing.

**Abbreviated forms of the names of all authors for bibliographic citation**

Kyawt Ngon Phu (Phu KN) Orawan Buranruk (Buranruk O) Neil Roberts (Neil R)

**Declarations of any conflicts of interest:**

The authors declare that there are no competing interests.

**Ethics Committee approval:**

The protocol was approved by the Research Ethics Committee (REC) of Khon Kaen University (KKU), Thailand, and the Department of Medical Research, which agreed on adjustments following the standard principles of the Declaration of Helsinki. All eligible participants signed consent forms.

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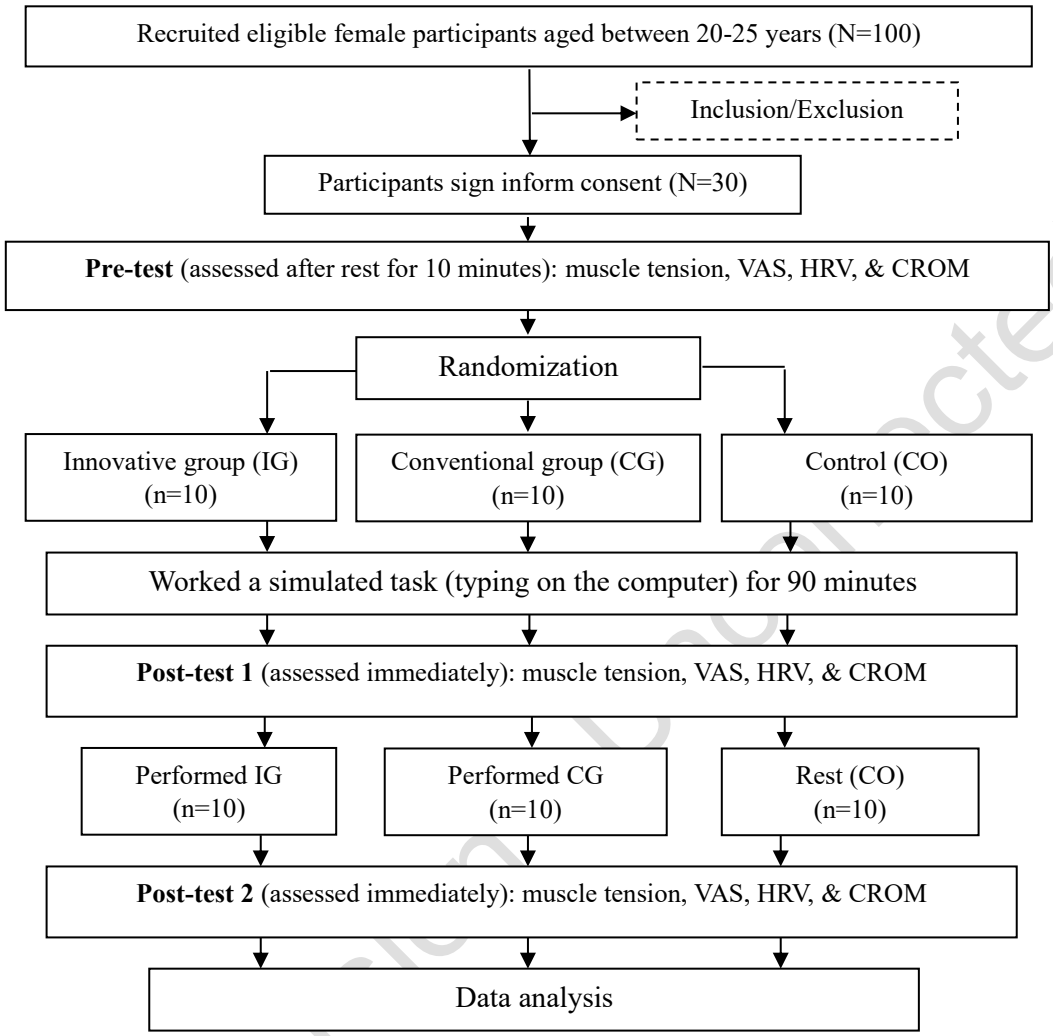


**Figure** 1. Flowchart of the study protocol and data collection steps.

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**Table 1.** Baseline characteristics of participants

| Characteristics | PRT (M ± SD) | EX (M ± SD) | CN (M ± SD) | p-value |
|---|---|---|---|---|
| Number | 10 | 10 | 10 | |
| Age (years) | 22.50 ± 1.96 | 21 ± 2.18 | 22.20 ± 1.99 | 0.81 |
| BMI (kg/m$^2$) | 20.13 ± 1.14 | 20.59 ± 1.67 | 20.28 ± 1.34 | 0.76 |
| Computer experience (years) | 9.00 ± 1.15 | 8.10 ± 2.13 | 9.40 ± 1.51 | 0.21 |
| Computer use per day (hours) | 4.70 ± 0.95 | 5.30 ± 1.34 | 4.90 ± 0.88 | 0.46 |
| VAS at rest (cm.) | 0.19 ± 0.50 | 0.33 ± 0.42 | 0.23 ± 0.36 | 0.76 |
| Muscle tension score at rest (cm.) | 1.11 ± 0.94 | 0.89 ± 0.50 | 1.15 ± 0.55 | 0.67 |
| HRV (ms$^2$) | | | | |
| LF | 5.77 ± 4.65 | 3.63 ± 2.35 | 3.55 ± 2.10 | 0.24 |
| HF | 5.84 ± 4.37 | 6.04 ± 3.42 | 6.80 ± 5.32 | 0.88 |
| LF/HF (ratio) | 2.84 ± 5.50 | 0.66 ± 0.43 | 0.57 ± 0.27 | 0.22 |
| CROM (degree) | | | | |
| Flexion | 52.00 ± 9.32 | 56.93 ± 6.36 | 49.82 ± 9.66 | 0.18 |
| Extension | 73.14 ± 8.79 | 64.27 ± 14.49 | 64.47 ± 11.59 | 0.18 |
| Rt. Lateral Flexion | 41.87 ± 4.85 | 38.87 ± 5.02 | 39.60 ± 5.73 | 0.42 |
| Lt. Lateral Flexion | 46.27 ± 6.09 | 40.27 ± 9.47 | 38.47 ± 7.15 | 0.08 |
| Rt. Rotation | 66.80 ± 6.65 | 62.47 ± 7.63 | 60.53 ± 5.58 | 0.12 |
| Lt. Rotation | 65.93 ± 6.92 | 62.53 ± 9.10 | 59.07 ± 5.00 | 0.12 |

Differences in baseline between the groups were tested via the one-way ANOVA statistic.

PRT group; EX group; CN: control group; BMI: body mass index; VAS: Visual analog scale; HRV: Heart rate variability; LF: Low frequency; HF: High frequency; CROM: cervical range of motion; M: mean; SD: standard deviation

Early Version - Uncorrected

**Table 2.** Within and between the groups: immediate effect of intervention and control group after ninety minutes of computer utilization on muscle tension, pain, heart rate variability, and neck movement

| **Outcomes measurement** | **PRT (n=10)** | **EX (n=10)** | **CN (n=10)** | **p-value (BG)** |
|---|---|---|---|---|
| Muscle tension score (cm.) | | | | 0.16 |
| Pre (M ± SD) | 3.70 ± 1.73 | 2.94 ± 2.23 | 2.83 ± 1.63 | |
| Post (M ± SD) | 1.20 ± 1.00 | 1.10 ± 1.57 | 1.81 ± 1.66 | |
| p-value (WG) | <0.01[a]*** | 0.01* | 0.01* | |
| VAS (cm.) | | | | 0.81 |
| Pre (M ± SD) | 1.89 ± 1.57 | 2.38 ± 1.69 | 1.87 ± 1.46 | |
| Post (M ± SD) | 0.49 ± 0.68 | 0.90 ± 1.27 | 0.79 ± 0.80 | |
| p-value (WG) | 0.01* | 0.01* | <0.01** | |
| HRV -LF ($ms^2$) | | | | 0.06 |
| Pre (M ± SD) | 4.58 ± 2.42 | 5.72 ± 5.08 | 2.65 ± 2.09 | |
| Post (M ± SD) | 9.43 ± 10.09 | 3.55 ± 2.42 | 3.72 ± 2.87 | |
| p-value (WG) | 0.03* | 0.17 | 0.20[a] | |
| -HF ($ms^2$) | | | | 0.09 |
| Pre (M ± SD) | 4.73 ± 2.95 | 6.05 ± 6.60 | 5.01 ± 5.12 | |
| Post (M ± SD) | 4.58 ± 3.50 | 5.46 ± 4.57 | 7.24 ± 6.84 | |
| p-value (WG) | 0.77[a] | 0.80 | 0.06 | |
| -LF/HF ratio | | | | 0.01[b]* |
| Pre (M ± SD) | 4.59 ± 5.47 | 1.48 ± 1.37 | 0.76 ± 0.71 | |
| Post (M ± SD) | 1.74 ± 1.85 | 0.77 ± 0.37 | 0.58 ± 0.45 | |
| p-value (WG) | <0.05* | 0.03* | 0.14 | |
| CROM - Flexion (degree) | | | | 0.09 |
| Pre (M ± SD) | 45.93 ± 12.58 | 48.33 ± 6.14 | 44.60 ± 9.12 | |
| Post (M ± SD) | 51.27 ± 11.37 | 50.13 ± 7.55 | 44.47 ± 7.58 | |

Early Version - Uncorrected

| Outcomes measurement | PRT (n=10) | EX (n=10) | CN (n=10) | p-value (BG) |
|---|---|---|---|---|
| p-value (WG) | <0.01[a]** | 0.41[a] | 0.93[a] | |
| - Extension (degree) | | | | 0.27 |
| Pre (M ± SD) | 65.94 ± 10.59 | 64.40 ± 15.13 | 63.27 ± 11.73 | |
| Post (M ± SD) | 69.87 ± 12.87 | 65.80 ± 14.68 | 62.87 ± 10.29 | |
| p-value (WG) | 0.06[a] | 0.58[a] | 0.67[a] | |
| -Rt. Lateral flexion (degree) | | | | 0.27 |
| Pre (M ± SD) | 36.27 ± 3.84 | 39.07 ± 7.08 | 36.33 ± 5.57 | |
| Post (M ± SD) | 40.73 ± 5.86 | 39.53 ± 4.90 | 39.03 ± 4.05 | |
| p-value (WG) | 0.03[a]* | 0.83[a] | 0.07[a] | |
| - Lt. Lateral flexion (degree) | | | | <0.01** |
| Pre (M ± SD) | 42.60 ± 4.21 | 40.87 ± 6.28 | 37.13 ± 5.96 | |
| Post (M ± SD) | 48.47 ± 6.50 | 43.47 ± 8.81 | 37.73 ± 5.68 | |
| p-value (WG) | <0.01[a]*** | 0.03[a]* | 0.51[a] | |
| - Rt. Rotation (degree) | | | | 0.16 |
| Pre (M ± SD) | 63.33 ± 5.54 | 61.93 ± 5.23 | 57.33 ± 7.08 | |
| Post (M ± SD) | 67.20 ± 6.88 | 61.47 ± 7.63 | 57.67 ± 7.34 | |
| p-value (WG) | 0.02[a]* | 0.84[a] | 0.77[a] | |
| - Lt. Rotation (degree) | | | | <0.01** |
| Pre (M ± SD) | 61.87 ± 10.13 | 58.20 ± 11.09 | 56.47 ± 6.80 | |
| Post (M ± SD) | 66.67 ± 9.39 | 62.80 ± 9.41 | 54.93 ± 6.57 | |
| p-value (WG) | 0.01[a]* | 0.01[a]* | 0.31[a] | |

[a] Pair sample t-test; [b] Kruskal-Wallis test

Early Version - Uncorrected

* significant level at 0.05; **significant level at 0.01; ***significant level at 0.005

PRT group; EX group; CN group; WG: within the group; BG: between the group; VAS: Visual analog scale; HRV: Heart rate variability; LF: Low frequency; HF: High frequency; CROM: cervical range of motion; M: mean; SD: standard deviation

Early Version - Uncorrected