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ORIGINAL RESEARCH **PAIN MANAGEMENT**

Intrarater reliability of cervical range of motion device in measuring cervical active range of motion in patients with chronic neck pain and respiratory dysfunction

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Abstract

Background: Assessment of cervical active range of motion (CAROM) in three planes was one of the primary outcome measures used by the clinicians.

Methodology: We enrolled 30 patients (14 males and 16 females) with chronic neck pain and respiratory dysfunction fulfilling inclusion criteria. Two trials of CAROM measurement for flexion, extension, left and right lateral flexion and left and right rotation were performed, with a gap of one week to measure test retest reliability of CROM device. Intraclass correlation coefficient (ICC), standard errors of measurement (SEM) and minimal detectable change (MDC) were calculated to test the intrarater reliability.

Results: Intrarater reliability of repeated measurements of CAROM using the CROM device was found to be good. The ICC values ranged between 0.88-0.97 for flexion, 0.93-0.98 for extension, 0.92-0.98 for right lateral flexion,0.93-0.98 for left lateral flexion. For right rotation it was 0.88-0.97, for left lateral rotation it was 0.95-0.99. The standard error of measurement for these movements ranged from 1.5° to 2.9°. Minimal detectable change ranged from 3.5°for extension to 6.8°for left lateral flexion.

Conclusion: Cervical range of motion device is a reliable tool for measuring cervical active range of motion in patients simultaneously suffering from chronic neck pain and respiratory dysfunction.

Abbreviations: CAROM - cervical active range of motion; CROM - cervical range of motion; ICC - Intraclass correlation coefficient; SEM - standard errors of measurement; MDC - minimal detectable change

Key words: Adult; Exercise Therapy / methods; Female; Humans; Male; Neck Pain / physiopathology; Neck Pain / therapy; Pain Measurement; Pulmonary function; Range of Motion, Articular; Reliability

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1. Introduction

Patients suffering from chronic neck pain can experience associated musculoskeletal disorders mostly due to compensatory postural adjustments and muscle activation patterns.[1,2] Emerging new technologies and gadgets are causing more postural problems than ever and are contributing to the increased prevalence of neck pain;[3] although any correlation between neck pain and the duration of usage of these devices is not established.[4,5]

Some chronic neck pain patients can also develop respiratory dysfunction.[6] In the recent past many studies have investigated the impact of chronic neck pain on respiratory functions.[7,8,9] Respiration is a multidimensional phenomenon which is influenced by number of factors such as biomechanical, biochemical, physiological, psychological and social.[10] Major neck related factors having negative influence on normal respiratory function are reported to be (a) the decreased strength of deep neck flexors and extensors, (b) the hyperactivity and increased fatigability of superficial neck flexors, (c) the limitation of range of motion of neck (d) the decrease in proprioception and disturbances in neuromuscular control of neck (e) the existence of chronic pain in neck and back and many other factors.[11,12,13,14]

Cervical spine has unique kinetics allowing movement in all six directions, i.e. flexion, extension, side flexion and rotation on both sides. It has a crucial role in supporting the weight of head and providing anchorage to the associated respiratory muscles proximally, so that they can participate in the necessary function of respiration on another end. Any alteration in the cervical spine kinetics can influence the action of one muscle over the other by altering force length curve, and thus altering their force exerting properties.[15,16] It is reported that chronic neck pain causes inhibition of core muscles of the neck (longus coli, longus capitis) and increased activation of superficial muscles such as sternocleidomastoid and anterior scalene.[17,18] As chronic neck pain patients assume a forward head posture a correlation study conducted on 33 healthy subjects demonstrated a strong negative correlation between craniovertebral angle and sternocleidomastoid activation ratio.[19] Muscular imbalance, postural changes and segmental instability due to weakness of deep neck muscles may contribute to thoracic spine instability and changes in rib cage mechanics.[20,21] Changes in Proprioceptive feedback, psychological influence of pain and resulting kinesiophobia can further exaggerate the respiratory dysfunction. Increased neck muscle fatigability, decreased cervical range of motion (CROM) due to pain can further contribute to changes in biomechanics of ribs which can finally lead to respiratory dysfunction.[6]

CROM is a valid objective outcome measure in clinical setups.[22] It not only helps in differentiating articular dysfunction from non-articular dysfunction but also it is one of the strongest parameters to be used as baseline assessment and to record progression in the treatment. Many studies have been conducted to assess quantitative measurement of cervical active range of motion.[23] The different studies have shown that the CROM device,[24] the Spin-T goniometer[25] and the universal goniometer,[26] were valid and reliable for this purpose.[24] Audette et al. compared the CROM device reliability in 20 healthy subjects with the fast track motion analysis system, and found that the test retest reliability of the CROM device was good with intraclass correlation coefficient (ICC) values ranging between 0.89-0.98.[27] A recent study by on healthy adults measured reliability of CROM device with a week interval and found it to be moderate to good with ICC values ranging between 0.65-0.[28] Many other studies have assessed the intrarater reliability of CROM device on healthy as well as patient population and concluded that results with CROM device were reproducible within the same session.[29]

Patients who suffer from chronic neck pain show a decline in optimal respiratory function and often assume a forward neck posture due to over activation of superficial neck flexors.[18] This posture somehow compromises the actual ranges measured with CROM device. Although the reliability of the CROM device has previously been evaluated in healthy subjects as well as in patients suffering from different conditions, but not in patients simultaneously suffering from chronic neck pain and respiratory dysfunction. Therefore, we evaluated the intrarater reliability of CROM device in patients simultaneously suffering from chronic neck pain and respiratory dysfunction.

2. Methodology

A total of 30 patients, consisting of 14 males and 16 females, suffering from neck pain and mild respiratory dysfunction were recruited through effect size method to

obtain a statistical power of 0.80 and an effect size of 0.6. After approval from ethical committee of University of Lahore, permission was also obtained from the hospital administration for data collection. The patients visiting physiotherapy department of the university hospital for the treatment of neck pain were recruited from March to August 2020. Written informed consent was obtained from each participant prior to the study.

Participants between the age of 25-50 years, with neck pain for more than 3 months, pain score of ≥ 3 on visual analogue scale (VAS), and FEV_1/FVC ratio between 60-69% of the predicted ratio were eligible for the study.

Figure 1: The cervical range of motion device (CROM)

The age range of 25-50 y was based on the fact that with increasing age the pliability of lungs gradually decreases. Mild pain < 3 is unlikely to be accompanied by a respiratory dysfunction. FEV_1/FVC% less than 60 is indicative of severe respiratory illness and value more than 69% is indicative of no respiratory dysfunction at all. FEV_1/FVC ratio was calculated through pulmonary function testing with a portable spirometer 'MIR Spirolab 4™', in sitting position by a trained respiratory technician. Whereas patients with neck pain of traumatic origin, and congenital deformity of cervical spine were excluded.[29] The 'CROM Basic' by Performance Attainment Associates™ is a device to measure cervical ROM during flexion/extension, left / right lateral flexion and left / right rotation (Figure 1). Two gravity-based inclinometers positioned in the sagittal and frontal planes, measure lexion/extension and lateral flexion, respectively. Whereas a magnet base compass like gadget positioned in the transverse plane

Figure 2: Placement of the CROM for lateral cervical flexion

Figure 3: Placement of the CROM measurement for Rotation

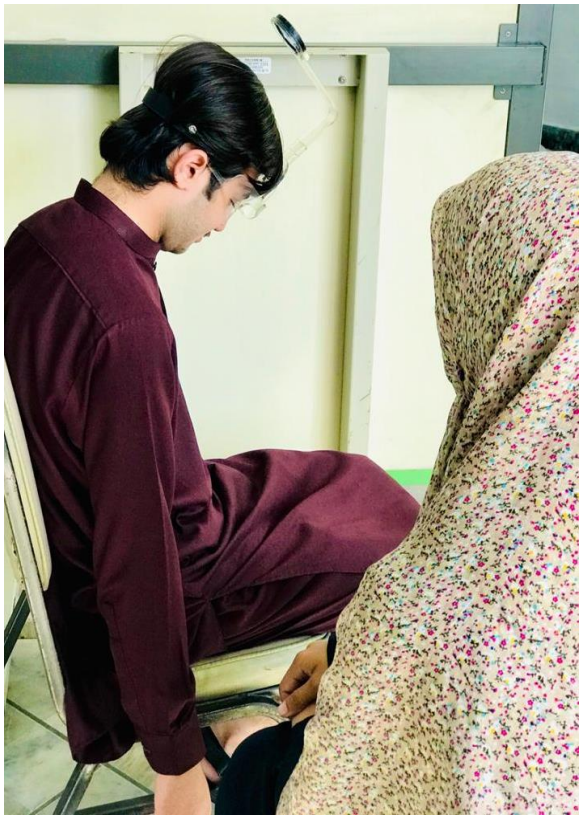

Figure 4: Placement of CROM for measurement of flexion. Please note the patient's posture.

above the head, measures cervical rotation movement with the help of magnets placed on the thorax. Both the inclinometers and the compass like gadget are attached to a plastic frame that fits on the head conveniently and is secured by Velcro straps.[30]

Six cervical movements; flexion/extension, left and right-side flexion and left and right rotations were demonstrated in front of each participant. Patients were thoroughly guided to maintain a neutral head and neck position with gaze pointing straight throughout the testing procedures. Starting position was a neutral head and neck position with straight back against a wooden chair, arms by the side while shoulders were relaxed and tilted backwards. Knees were bent at 90° while feet lied flat on the ground. Patients were asked to perform all six movements with evaluator's cues to get familiar

with the whole test. For flexion and extension patient was guided to perform full range flexion after tucking the chin in (Figure 2). Similarly, extension was performed after chin raised up to participants' limit. For side flexion and rotations patients were advised not to move their shoulders and look forward (Figure 3, Figure 4).

CROM device was placed on the patient's head with adjustment of nose clip and magnetic collar was hanged around shoulder to prevent any rotation of the trunk. The patients were asked to perform all six cervical range of movements. The order of the movement performed was randomly picked by every patient from

a list of all six movements. For flexion /extension and both side flexions relevant dial of inclinometer was read by the author at start of the movement and at the end range. For rotation, dial was set at zero and movement was performed in the same manner. Values were recorded by the recorder. The same set of measurements was performed one week after the first measurement. The order of the measurement was randomized by a similar method and evaluator was blind about the previous values. Recorder bias was minimized by testing of active range of motion (AROM) which is purely under patient's control. Procedure was performed by a registered physical therapist who had specialized in orthopedic manual physical therapy with 10-year clinical experience, including the use of CROM.

Statistical analysis

Data was analyzed using SPSS software version 21.

Normality of data was checked through histograms, which was normally distributed. Descriptive statistics were calculated in the form of means and standard deviations for the age, VAS score, FEV_1/FVC ratio and for all six ranges of motion of neck.

To determine the test-retest reliability of the CROM measurements, the ICC mixed model 3,1 designated as 2 -way analysis of variance (ANOVA) for absolute agreement of single measure with 95% confidence interval (CI) was used.

The standard error of the measurement (SEM) was calculated using the following formula;

$SEM=SD\sqrt{1-r\alpha}$. (r; reliability of the measure).[34] The minimal detectable change at the 90% CI was calculated as MDC90 equals 1.65(z score for 90%CI)*SEM*$\sqrt{2}$.

3. Results

Based on the inclusion and exclusion criteria, 30 subjects, (14 male and 16 females) were included in the study. Descriptive statistics of the baseline values are described in Table 1.

Table 1: Demographic and descriptive baseline values

Parameter	Value (Mean ± SD)
Age(y)	38.73 ± 5.66
Gender (M:F)	14:16
VAS score	2.83 ± 0.59
FEV1/FVC (%)	64.76 ± 2.19
Height (cm)	158.1 ± 6.33
Weight (kg)	64.85 ± 8.15
BMI (kg/m^2)	25.84 ± 1.51

VAS - visual analogue scale; FEV1/FVC - Forced expiratory volume in 1 min/ forced vital capacity; BMI -Body Mass Index

Table 2 shows the descriptive and intrarater reliability statistics for measurements of cervical active range of motion (CAROM) in patients with chronic neck pain and respiratory dysfunction in session 1 and session 2. The intraclass coefficient values for intrarater reliability were; flexion 0.94 (0.88-0.97), extension 0.97 (0.93-0.98), right lateral flexion 0.96 (0.92-0.98), left lateral flexion 0.96 (0.93-0.98) right rotation 0.94 (0.88-0.97) and left lateral rotation 0.95 (0.95-0.99). The standard error of measurement ranges from 1.5° to 2.9°. Standard error of measurements were; flexion 2.6° extension 1.5°, right lateral flexion 2.9°, left lateral flexion 2.9°, right rotation 2.5° and left rotation 2°.

4. Discussion

This study was conducted to assess the reliability of results by CROM device in patients simultaneously suffering from neck pain and respiratory dysfunction. According to the results it is clear that ICC values were greater than 0.90, which show that CROM device for calculation of CAROM in patients with neck pain and respiratory dysfunction has excellent reliability. The intraclass coefficient above 0.90 for all six ranges lies in excellent range according to ICC model interpretation.[32]

Wolan et al. assessed inter and intrarater reliability of CROM device on 95 healthy individuals between ages of 20-24 y, and the difference at two weeks in retesting. According to their findings highest intrarater and measured passive range of motion as well. In another study CROM device was found useful in repositioning head accuracy and reliable in measurement of cervical ranges in patients with cervical radiculopathy.[36]

Table 2: Descriptive and intrarater reliability statistics for measurement of CAROM in patients with chronic neck pain and respiratory dysfunction using CROM device

Movement	Session-1 (Mean ± SD)	Session-2 (Mean ± SD)	ICC	95%CI for ICC	SEM	MDC 90%CI
Flexion	43.63 ± 2.76	43.86 ± 2.63	.94	0.88-0.97	2.6°	6.1°
Extension	52.56 ± 2.50	53.36 ± 2.48	.97	0.93-0.98	1.5°	3.5°
Right lateral flexion	41.73 ± 2.11	42.23 ± 1.97	.96	0.92-0.98	2.9°	6.8°
Left lateral flexion	42.06 ± 2.04	42.26 ± 1.98	.96	0.93-0.98	2.9°	6.8°
Right rotation	42.26 ± 1.04	42.46 ± 1.10	.94	0.88-0.97	2.5°	5.8°
Left rotation	42.56 ± 1.45	42.76 ± 1.40	.95	0.95-0.99	2.0°	4.7°

Abbreviations: AROM, active range of motion: SD, standard deviation; ICC, intraclass correlation coefficient, model 3,1; SEM, standard error of the measurement; MDC minimal detectable change at 90% confidence level

interrater concordance was observed in the measure of extension. Result of the present study shows similar trend where ICC value for cervical extension (0.97) was the highest when compared to ICC values from the other five analyzed movements. However, healthy population with age (20-25 y) was included in their study. Our study was different than previous CROM reliability studies as it was conducted in patients who suffered from neck pain along with respiratory dysfunction and investigated the CAROM in all six possible ranges with strict protocols and clear methods.[33]

The results of this study are in coherence with another study on neck pain patients in which average ICCs for CROM device was greater than 0.80; whereas, ICCs values for universal goniometer and visual estimation were less than 0.80.[34] The three tools (CROM device, universal goniometer and visual screening) were used in 3 data collection sessions and 60 subjects were tested in three groups having 20 subjects in each group. However, the methodology of this study is different in terms of measurement of six planes of CAROM instead of a single plane in the said study. In a study for reproducibility of cervical active and passive range measurements after sub-acute whiplash disorder CROM device was found to be a reliable tool with ICC range (0.82-0.99).[35] In this study 39 and 19 subjects were tested for intra and inter-observer studies respectively, both active and passive cervical ranges were measured and CROM was proved to be a reliable device for symptomatic neck pain patients. Apart from reliability measurement calculation of SEM and MDC are additional merits of this study; however, only active cervical ranges were observed, whereas Williams et al. According to a systematic review by Williams et al. in a number of studies reliabilities of CROM device has been proved. Fifty-six studies were reviewed and 12 different methods were evaluated. Most of the studies were conducted on healthy population or to measure a single particular range such as flexion-extension of neck or forward head posture. In another study, researchers evaluated the intrarater reliability of CROM device for measuring proprioception of cervical spine in healthy individuals and described it to be a reliable tool.[37] Apart from the difference of neck pain population studied in this study it has an additional merit of measuring standard error of measurement and minimal detectable change, which was lacking in the study by Reddy et al. In another study CROM device showed high reliability in patients suffering from migraine but only 50 young females with average age 35 y were studied.[38] Our study minimized the gender bias by including both genders.

5. Limitations

We measured only the intrarater reliability, in a small sample. Future researchers should explore this phenomenon with large population assessing both interrater and intrarater reliability. It is necessary to rule out more factors which may influence the objective outcome measures of cervical spine due to coexistence of respiratory dysfunction.

6. Conclusion

CROM device is a reliable tool for intrarater analysis in measuring cervical active range of motion in patients with chronic neck pain and respiratory dysfunction.

This device seems to be reliable in measuring cervical active range of motion in all six directions.

7. Trial registration

Registered as Trial No. IRCT 20200226046623N1 https://www.irct.ir/trial/46240

8. Data availability

The numerical data generated in this study is available with the authors.

9. Disclaimer

This study is based on an ongoing trial conducted as a part of PhD study at University of Lahore.

10. Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

11. Conflict of interest

None declared by the authors.

12. Author contribution

SA: Conception and design of the study, Data collection, Data interpretation, Drafting

HZ: Drafting

AA: Data interpretation, Drafting

AH: Statistical Analysis

All authors read the final draft and approved.

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