Intra-Examiner and Inter-Examiner Reliability of Goniometer for Active Cervical Contra-Lateral Flexion and Algometer for Pressure Pain Threshold in Upper Trapezius Muscle in Asymptomatic Young Adult Women

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Abstract

Introduction: Measurement of Active Cervical Contra-Lateral Flexion (ACCLF) and Pressure Pain Threshold (PPT) is an integral part of the patients' assessment with myofascial pain syndrome and cervical disorders. This study aimed to investigate the inter- and intra-examiner reliability of goniometer in measuring ACCLF and algometer in measuring PPT in the upper trapezius muscle. **Materials and Methods:** ACCLF and PPT in upper trapezius muscle were measured in 20 healthy young adult female volunteers. Measurements were performed in two sessions one hour apart by two examiners, each consisting of 3 trials with 60-second rest periods. Data analysis was performed using the Interclass Correlation Coefficient (ICC) and Standard Error of Measurement (SEM). **Results:** For ACCLF measurement with the goniometer, the intra-examiner reliability was as follows: first examiner in first session=0.985, first examiner in second session=0.959, and the inter-examiner reliability was first session=0.954 and second session=0.969. For PPT measurement with the algometer, the intra-examiner reliability was as follows: first examiner in first session=0.928, first examiner in second session=0.877 and the inter-examiner reliability were: first session=0.742 and second session=0.866. **Conclusion:** Goniometer and algometer exhibited a good inter- and intra-examiner reliability in measuring ACCLF and PPT, respectively, in the upper trapezoid muscle.

Keywords: Cervical Contra-lateral Flexion; Inter-examiner; Intra-examiner; Pressure Pain Threshold; Reliability

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Introduction

Healthcare systems consider pain as a primary factor of quality of life (1) and allocate large annual budgets to medical equipment and therapeutic modalities with pain reduction purposes. The efficacy of these interventions and equipment cannot be evaluated without a reliable tool for measuring pain (2). Hence, physiotherapists need some standardized methods and instruments with a high validity and reliability in the pain measurement.

Measuring the range of motion (ROM) of Active Cervical Contra-Lateral Flexion (ACCLF) is an integral part of the clinical assessment of patients with neck trauma or pain. This measurement is of great importance for physiotherapists as it allows them to (i) determine the extent of limitation in the ROM before starting intervention, (ii) choose and plan the appropriate therapeutic intervention, and (iii) assess the efficacy of the chosen intervention (4). Since almost all patients with neck pain suffer from the reduced cervical ROM, evaluating the ROM of the cervical spine and restoring its normal range are key objectives of the therapeutic physiotherapy process (5). Cervical ROM can be measured by visual examination, tape measure, inclinometer, electro goniometer, radiography, computerized thermography, and cervical ROM instrument, each having its own advantages and disadvantages (3, 11).

Table 1. Mean, standard deviation and range of demographic variables for age, height, weight, and BMI (n=20)

Variable	Mean (SD)	Min	Max	Range
Age (years)	22.35 (2.85)	19	30	11
Height (cm)	162.15 (5.91)	150	172	22
Weight (kg)	57.52 (10.49)	42	84	42
BMI (kg/m²)	21.81 (3.40)	17.84	28.57	10.73

Table 2. ICC and SEM values calculated for quantifying the intra-examiner reliability of algometer in measuring PPT (n=20)

Description	95% Confidence Interval for ICC	ICC	SEM	MDC
Algometer, 1st Examiner, 1st session, 1st trial	0.856-0.968	0.928	0.703	1.950
Algometer, 1st Examiner, 2nd session, 1st trial	0.763-0.945	0.877	0.000	0.000
Algometer, 1st Examiner, 1st session average	0.769-0.960	0.902	0.818	2.268
Algometer, 2nd Examiner, 1st session, 1st trial	0.708-0.930	0.846	0.969	2.687
Algometer, 2nd Examiner, 2nd session, 1st trial	0.643-0.911	0.806	1.040	2.885
Algometer, 2nd Examiner, 1st session average	0.780-0.962	0.907	0.756	2.098

ICC: Intraclass Correlation Coefficient; SEM: Standard Error of Measurement; Minimal Detectable Change (MDC); PPT: Pain Pressure Threshold

Table 3. ICC and SEM values calculated for quantifying the inter-examiner reliability of algometer in measuring PPT (n = 20)

Description	95% Confidence Interval for ICC	ICC	SEM	MDC
Algometer, 1st Examiner, 1st session average	0.455-0.889	0.742	1.327	3.680
Algometer, 1st Examiner, 2nd session average	0.693-0.945	0.866	0.731	2.027

PPT: pressure pain threshold

Table 4. ICC and SEM values calculated for quantifying the intra-examiner reliability of goniometer in measuring ACCLF (n=20)

Description	95% Confidence Interval for ICC	ICC	SEM	MDC
Goniometer, 1st Examiner, 1st session, 1st trial	0.968-0.993	0.985	1.028	2.851
Goniometer, 1st Examiner, 2nd session, 1st trial	0.917-0.982	0.959	1.503	4.167
Goniometer, 1st Examiner, 1st session average	0.930-0.989	0.972	1.418	3.931
Goniometer, 2nd Examiner, 1st session, 1st trial	0.976-0.995	0.988	0.937	2.598
Goniometer, 2nd Examiner, 2nd session, 1st trial	0.949-0.989	0.975	1.356	3.761
Goniometer, 2nd Examiner, 1st session average	0.948-0.992	0.979	1.251	3.468

ACCLF: Active Cervical Contra Lateral Flexion

Table 5. ICC and SEM values calculated for quantifying the inter-examiner reliability of goniometer in measuring ACCLF (n=20)

Description	95% Confidence Interval for ICC	ICC	SEM	MDC
Algometer, 1st Examiner, 1st session average	0.887-0.981	0.954	1.817	5.038
Algometer, 1st Examiner, 2nd session average	0.925-0.988	0.969	1.374	3.810

ACCLF: Active Cervical Contra Lateral Flexion

Recent studies have suggested that patients with the myofascial pain syndrome in their neck and shoulder region have a lower pressure pain threshold (PPT) than healthy people (6). In recent years, several measures including PPT, thermal pain threshold, pressure pain tolerance, and thermal pain tolerance have been used to quantify pain sensitivity (8, 9). PPT has been defined as the minimum amount of pressure required to elicit a sense of pain distinct from the sense of pressure or discomfort (7).

Although the choice of measurement instrument involves considerations such as cost, ease of use, and availability, the most important factors in this regard are the reliability and validity of the instrument measurements (10). Despite the widespread use of digital goniometers and algometers, few studies have investigated the inter- and intra-examiner reliability of these instruments. Hence, the inter- and intra-examiner reliability of these digital instruments needs to be examined further. This study aimed to investigate the inter- and intra-examiner reliability of goniometer in measuring ACCLF and algometer in measuring PPT in the upper trapezius muscle.

Materials and Methods

Participants

This Quasi-experimental study was conducted with the approval of the ethics committee of Shahid Beheshti University of Medical Sciences (code: IR.SBMU.RETECH.REC.1396.278). In the present study, due to matching samples in terms of demographic, anthropometric characteristics, muscle tissue, and pain tolerance, the subjects were female between 18 to 30 years old.

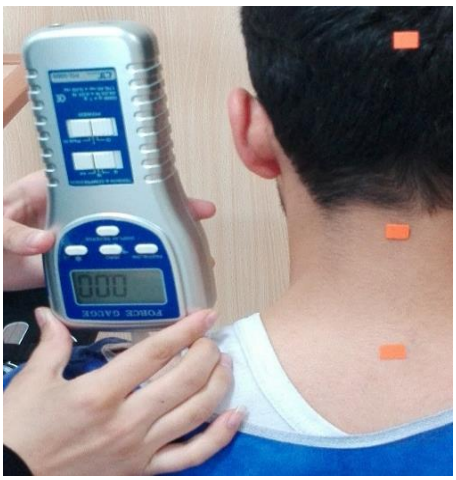

Figure 1. Measurement of the pressure pain threshold (PPT)

Before any tests, volunteers were asked to fill out the informed consent form and a questionnaire enquiring about the inclusion criteria, were fully informed about the method and purpose of the study, and were assured that they can leave the research at any time at their own discretion. The measurements were performed in 2018 on 20 volunteer students residing at the dormitory of Shahid Beheshti University of Medical Sciences. All measurements were performed in two sessions, each consisting of three trials, with a one-hour interval between sessions.

Based on information from similar studies, the sample size was calculated to 20 (13). Inclusion criteria were as follows (11): age between 18 and 30 years, no history of pain in the neck and shoulder region in the past month, no history of neck whiplash, no history of fracture, surgery, and radiculopathy, absence of structural deformities such as forward head posture (FHP), and rounded shoulder. Table 1 presents the participants' demographic and anthropometric characteristics.

Instruments

In the present study, PPT was measured using a digital algometer (Lutron FG-5020) capable of measuring tensile and compressive forces of up to 20kg with a precision of 0.01. This device digitally records the pressure exerted on an intervertebral disk of 1 cm^2 in diameter. The cervical contra-lateral flexion ROM was measured using the Goniometer No. 1 manufactured by Sihan Co., which consisted of a 360-degree protractor and two 30-cm arms, one fixed and another mobile, both with centimeter and millimeter markings.

Algometer

For measurement with the algometer**,** the subject was asked to sit on a chair with shoulders relaxed and arms hanging beside the body. The examiner placed the algometer on the previously marked point on the upper trapezius and applied progressively increasing pressure until the subject felt a pain (Figure 1).

To find the point of application of the force, the examiner found the spinous process of C7 by the palpation and marked it, found and marked the outer end of the acromion, measured the distance between these two points, and marked the midpoint between them.

To make the subjects familiar with the algometer and make sure that they can distinguish pain from the pressure elicited by the instrument, first, the device was used to apply progressively increasing force on the midpoint between anterior superior iliac spine and superior pole of the patella (on the quadriceps muscle) and the subjects were asked to inform the examiner by saying "now" as soon as they felt pain. The measurements were performed in two sessions exactly one hour apart, each consisting of 3 trials with 60-second rest periods. The same procedure was repeated by the second examiner.

Goniometer

To measure the cervical contra-lateral flexion ROM, the participant was asked to sit straight on a chair with shoulders relaxed and arms placed on the armrest. Standing behind the subject, the examiner placed the center of the goniometer on the spinous process of C7. With one arm of the goniometer kept completely vertical and the other arm kept parallel to the inferior nuchal line, the subject was asked to perform the contra lateral flexion without artificial movements such as shoulder lift, rotation, neck flexion and extension, or moving the ear toward the shoulder. As before, the measurements were performed 3 times with 60-second rest period for two sessions with 1-hour interval between sessions. The same procedure was repeated by the second examiner (Figure 2).

Statistical Analysis

Data analysis was performed using SPSS version 16. Inter-examiner reliability and intra-examiner reliability were quantified using the interclass correlation coefficient (ICC) at a 95% confidence interval. Absolute reproducibility was quantified using the standard error of measurement (SEM). The standard error (SE) of a statistic (usually an estimate of a parameter) is the standard deviation of its sampling distribution or an estimate of that standard deviation. If the parameter or the statistic is the mean, it is called the SEM (22).

Results

Tables 2-5 present the mean, standard deviation, range, ICC, and SEM of the measurements of the cervical contralateral flexion with goniometer and PPT with algometer.

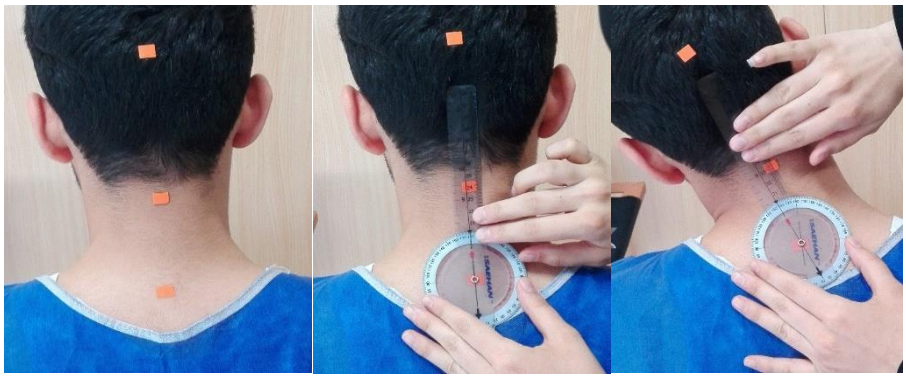

Figure 2. Measurement of the cervical contralateral flexion ROM

According to the classification proposed by Rosner, ICC values of less than 0.40 reflect poor reliability, ICC values of between 0.40 and 0.75 signify moderate reliability, and ICC values of more than 0.75 are indicative of good reliability (14).

As shown in Table 2, the intra-examiner reliability of the PPT measurements made by the first examiner is: 'first session ICC&SEM=0.928-0.703' and 'second session ICC&SEM=0.877-0.000'. For the PPT measurements made by the second examiner, these figures are: 'first session ICC&SEM=0.846-0.969' and 'second session ICC&SEM=0.806-1.040'. According to the Rosner criteria, all of these values signify good reliability. As Table 3 shows, the inter-examiner reliability of the PPT measurements made by the two examiners was calculated to: 'first session ICC&SEM=0.742-1.327' and 'second session ICC&SEM=0.866-0.731'. According to the Rosner classification, these results are indicative of moderate-good reliability. As shown in Table 4, the intra-examiner reliability of the ACCLF measurements made by the first examiner is: 'first session ICC&SEM=0.985-1.028' and 'second session ICC&SEM=0.959-1.503'. For the PPT measurements made by the second examiner, these figures are: 'first session ICC&SEM=0.988-0.937' and 'second session ICC&SEM=0.975-1.356'. According to the Rosner classification, these values represent good reliability. According to Table 5, the inter-examiner reliability of the ACCLF measurements made by the two examiners was calculated to: 'first session ICC&SEM=0.954-1.817' and 'second session ICC&SEM=0.969-1.374', which both classify as good according to the Rosner classification.

Discussion

Measuring the active ROM of the cervical spine is an important part of the clinical evaluation of patients with cervical symptoms and neck pain. It is difficult to make reliable and accurate measurements of cervical spine ROM, as there is no significant bone landmark in the soft tissue around the spine segments of this region (3). This is why physiotherapists have long been interested in the ways to make accurate and reliable measurements in this region.

Applying pressure on tender areas to assess the pain sensitivity in patients is one of the methods of diagnosis for myofascial pain syndrome, trigger points, tender points of fibromyalgia, fibrosis, and tender spots (7). Pressure algometry is a more reliable pain threshold assessment method than palpation and is able to provide objective, quantitative, and comparable results (12). This study was focused on the reliability of measurements made with a digital algometer, which has found extensive use for ROM measurement because of its ease of use and reasonable price (11), and digital goniometer, which is a portable instrument for measuring the maximum pressure tolerance of patients (9).

The study investigated the intra-examiner and inter-examiner reliability of goniometer for measuring ACCLF and algometer for measuring PPT. The obtained ICC and SEM values indicated that both instruments enjoy a good reliability. In the following, we reviewed several other studies which have investigated the reliability of algometer and goniometer.

Evidence on the reliability of algometry measurements

The results of this study are consistent with the finding of Fischer *et al.*, who reported the excellent validity and reproducibility of algometry in measuring PPT in normal muscles (7). These results are also consistent with the report of Russell *et al.* on the reliability of algometry for patients with fibromyalgia syndrome, with the difference that Russell's study used the digital pressure-tender point index (TPI) and the average pain threshold (APT) for the algometry assessment. That study showed that while both methods are reliable, there are some differences between them (15). Our

results are also in agreement with the findings of Pöntinen *et al.*, however, this study also advised that using a standardized measurement method and equipment is essential for the algometric measurements to be valid and reliable (16). Our results are also consistent with the findings of Chesterton *et al.*, where the inter-rater reliability of algometry in measuring PPT in young healthy people was quantified with the help of several examiners, and it was reported that trained examiners can measure the PPT of healthy people with high reliability and at a steady speed (17). In a study by Ylinen *et al.* on the intra-examiner reliability of pressure algometry of cervical muscles for clinical use, the findings demonstrated a good intra-examiner reliability of pressure algometry, which is consistent with our results (18). Our findings are also in agreement with the results of a study conducted by Kinser *et al.* to investigate the validity and reliability of pressure algometer. This study showed a high correlation between the outputs of algometer and force gauge (9). Finally, a study by Zamani *et al.* has demonstrated the high intra-examiner reliability of algometer in measuring PPT and pain sensitivity in upper trapezius for asymptomatic young adult women, which is consistent with our results (12).

Evidence on the reliability of goniometer measurements

The results of this study regarding the reliability of goniometer measurements are partially consistent with the finding of Youdas *et al.*, who investigated the inter- and intra-examiner reliability of three methods of measuring the cervical spine ROM (goniometer, cervical ROM, and visual estimation) and reported a good reproducibility for cervical ROM, poor to moderate reproducibility for goniometer, and poor reproducibility for visual estimation. In contrast, our results showed that goniometric measurements have good reproducibility, provided that they are performed by one examiner (19).

A study by Tousignant *et al.*, which assessed the validity of the cervical ROM goniometer in measuring the cervical flexion and extension in a healthy population as compared to radiography, showed that this goniometer is a perfectly valid instrument for the said purpose. This study differs from the present study in the method of work and the measured ROM (20). In a review paper published by Kelvin Jordan (2000), where they investigated the evidence on the reproducibility of cervical spine ROM measurement instruments, it was stated that although these instruments enjoy a good reproducibility and are quite popular, there is still needed for more accurate studies with some potential confounding factors taken into consideration. The present study was conducted in response to this need (21). In the end, it should be noted that a study by Zamani *et al.* also examined the intra-examiner reliability of goniometer in measuring all active cervical spine movements in asymptomatic young women aged 18 to 30 years. According to the results of that study, the goniometer has acceptable intra-examiner reliability in measuring flexion, extension, rotation, and lateral flexion to the right and left (11).

This study had also limitations for example: limited age range, small size of the sample, lack of an analysis of between-day reproducibility, and the asymptomatic condition of the subjects studied. The authors suggest the following guidelines for the accurate measurement of cervical ROM and PPT:

1. Mark the exact location of the landmark with a marker
2. Use a transparent plastic goniometer to ensure better marker visibility and instrument flexibility
3. Inform a patient about the measurement process before the actual measurement and prevent artificial movements
4. Make sure that patient can distinguish between pain and pressure on muscle before the measurement process
5. Make sure that patient assumes and maintains proper posture during the measurement process
6. Allow a brief rest period between subsequent movements in order to prevent interference from the effects of the previous movement.

Conclusion

The results of this study demonstrated the acceptable intra-examiner and inter-examiner reliability of goniometer for measuring Active Cervical Contra-Lateral Flexion (ACCLF) and algometer for measuring Pressure Pain Threshold (PPT) in the upper trapezius for asymptomatic young adult women.

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None

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Authors' contributions:

All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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