Research Paper

Reproducibility of the Ultrasonography in Measuring the Cross-section of the Longus Colli in Patients With Non-specific Neck Pain

Afsaneh Samiei[1*], Mohammad Hosseinifar[1, 2], Fateme Ghiasi[1, 2], Hasan Namvar[1, 2], Ahmadreza Asgari Ashtiani[1, 2]

1. Department of Physiotherapy, School of Rehabilitation, Zahedan University of Medical Sciences, Zahedan, Iran.
2. Rehabilitation Research Center, Zahedan University of Medical Sciences, Zahedan, Iran.

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ABSTRACT

Purpose: Ultrasonography (US) can be used to measure the dimensions and the cross-section of muscles. This study aims to investigate the intra- and inter-tester reproducibility of the US measures of the cross-section of the longus colli (LC) muscle at rest and in contraction states in patients with chronic non-specific neck pain (CNSNP) and healthy individuals.

Methods: This cross-sectional study was conducted on seven healthy individuals and seven patients with chronic non-specific pains. The cross-section of the LC muscle was measured at rest and in contraction states at the C5-6 vertebrae by two raters using the US on two consecutive days. The data were analyzed by the Pearson correlation coefficient (ICC).

Results: The intra-tester reproducibility was excellent in the healthy (ICC>0.97) and patient (ICC>0.95) groups at rest and in contraction. The inter-tester reproducibility was great in the healthy group (ICC>0.97) in both states and at rest (ICC=0.98) and in the contraction (ICC>0.95) in the patient group.

Conclusion: The results revealed that the US demonstrated higher agreement in measuring the cross-section of the LC in healthy subjects and patients with CNSNP. Thus, this method is reliable and can be used to measure the cross-section of the muscles.

*** Corresponding Author:**
Mohammad Hosseini Far, Assistant Professor.
Address: *Department of Physiotherapy, School of Rehabilitation, Zahedan University of Medical Sciences, Zahedan, Iran.*
Phone: *+98 (915) 3404359*
E-mail: *fardash_s@yahoo.com*

Highlights

- The intra-tester reproducibility was excellent in the healthy group (ICC>0.97).
- The intra-tester reproducibility was excellent in the patient group (ICC>0.095) at rest and in contraction.
- The inter-tester reproducibility was excellent in the healthy group (ICC>0.97) in both states.
- The inter-tester reproducibility was excellent at rest (ICC=0.98) and in the contraction (ICC>0.95) in the patient group.

Plain Language Summary

The deep flexor muscles of the neck region have a special role in the stability of the spine, and the function of these muscles, especially the longus colli (LC), is impaired in neck pain patients. Measuring the dimensions of these muscles in healthy people with neck pain can clarify the role of these muscles in the stability of the spine. Ultrasonography (US) is a non-invasive method without damaging the muscles and with easy access to evaluate the deep muscles. Therefore, this study was conducted to investigate and compare the reproducibility of measuring the LC muscles in healthy individuals and patients with chronic neck pain using the US by two evaluators on two consecutive days. The results of this study show that the US is a valid tool with high reproducibility to measure the cross-section area of the deep flexor muscles in both resting and contracting states. Therefore, the US can be used to investigate the effect of exercises and other treatment methods on the size of the LC muscle in neck pain patients.

Introduction

The prevalence of neck pain is reported to be 67%-71%, which suggests that around two-thirds of society experience neck pain during their lifetimes [1]. The longus colli (LC) muscle as a deep flexor muscle lies in the anterior part of the spinal cord and is composed of three parts. It helps to flex the neck vertebrae when the two sides of it contract [2]. If this muscle experiences a dysfunction, it may reduce strength and tolerance in patients with neck pain [3-5]. The size of the cervical multifidus (MF) and LC muscles in patients with chronic radicular neck pain is more non-tender than in healthy individuals [6]. Because the size of the deep neck flexor muscles can determine their functions, ultrasonography (US) can be used to measure the cross-section and dimensions of these muscles [7, 8]. The US is the most economical and convenient method for muscle dimension evaluation. This technique works extraordinarily well and measures muscles at rest and different contraction states [9-13].

It is essential to check the reliability of the tools required for clinical measurements [14]. Therefore, it is necessary to evaluate the reproducibility of US to measure the dimensions and cross-sectional area of muscles.

Few studies have examined the intra- and inter-tester reproducibility of the cross-sectional size of the LC muscle using US. Almeida et al. investigated the intra- and inter-tester reproducibility of the US method to measure the cross-section of the LC muscle in women with migraine [15]. In their study, some poor agreement was noted based on the confidence interval. O'Riordan et al. investigated the reproducibility of US to measure the cross-section of the LC in healthy subjects using amateur and experienced users [16]. The intra-tester reproducibility was excellent compared to the moderate inter-tester reproducibility. Mohseni et al. showed that intra-tester reproducibility for the thickness of the LC muscle was good to excellent and inter-tester reproducibility was also good [17].

The LC muscle plays a special role in stabilizing the neck and its dysfunction in patients with neck pain. Thus, it is essential to use a valid and credible method to investigate the dimensions and functions of this muscle. Moreover, the US has been widely used to measure muscles in recent years, but sufficient studies are not available on the intra- and inter-tester reproducibility of the US method in measuring the cross-sectional area of the LC muscle, especially in the contraction state in patients with neck pain. Therefore, this study was conducted to investigate the intra- and inter-tester reproducibility of the US method to measure the cross-section of this muscle at rest and in contraction positions.

Materials and Methods

This study was conducted on seven patients aged 18-40 years (Mean±SD age: 32±8.28 years) with CNSNP and seven healthy subjects aged 18-34 years (Mean±SD age: 28±6.53 years), selected via convenience sampling. The healthy subjects were included with no previous history of neck pain or damage. The inclusion criteria of the patient group included patients with chronic pain and bilateral neck symptoms, passing 12 weeks from pain, and a lack of previous history of regular neck and upper limb exercises in the last 3 months. The exclusion criteria included patients with fibromyalgia, a previous history of cervical spinal cord surgery, severe neck osteoarthritis, cervical ribs, previous trauma or whiplash injury, neck radiculopathy, and myelopathy.

People were lying on the back while the knees and thighs were bent, the soles of the feet were on the floor and the arms were placed on both sides of the body. The bag of pressure biofeedback was placed under the neck, and a folded piece of towel was laid under the back of the head area. The towel did not contact with the bag of pressure biofeedback. In this state, the base pressure of the pressure biofeedback was adjusted at 20 as the resting pressure, and the individual was required to perform the nodding movement without engaging the sternocleidomastoid muscle without raising the head from over the bed while maintaining the position for 10 s. The number showed by the pressure biofeedback was recorded and the individual was asked to do the same move 10 times. During the ultrasound implementation, the patient performed the nodding movement under the contraction state to obtain the hand of the sphygmomanometer to be placed on the same previously recorded number. The cross-section of the deep neck flexor muscle was measured using an ultrasound device (The Toshiba Aplio 300 Model) with a linear probe of 4 cm and a frequency of L3-12A. In the imaging procedure, the center of the thyroid cartilage was first touched by hand and then marked by a marker. The center of the ultrasound probe, while being perpendicular and tangent to the neck axis, was moved 1 cm outward. The LC muscles were bordered in the lower and inner parts by the vertebrae body, in the outer direction by the carotid artery, and the upper part by the retropharyngeal space. Both raters took two images from each side in one day, one at the rest state and one in the contraction state to examine inter-tester reproducibility while the same procedure was performed the next day to examine intra-tester reproducibility.

Using the SPSS software, version 16, inter- and intra-tester reproducibility was analyzed with the Pearson correlation and interclass correlation coefficient (ICC). According to this classification, ICCs <40%, 40%-75%, and >75% were grouped as poor, moderate, and excellent reliability, respectively [18].

Results

This study was conducted on 14 subjects, including seven patients with CNSNP and seven healthy subjects. The demographic characteristics of the participants are provided in Table 1. For both raters, excellent intra-tester reproducibility was found in the healthy subjects at rest and in contraction states (ICC≥0.97) (Table 2). For the first rater, the intra-tester reproducibility values of the patient group at rest and in contraction states were ICC=0.98 and ICC≥0.95, respectively. For the second rater, the intra-tester reproducibility values of the patient group at rest and in contraction states were ICC≥0.98, and ICC≥0.96 (Table 3), respectively. The inter-tester reproducibility values of healthy subjects at rest and in contraction states were ICC=0.99 and ICC≥0.97, respectively, while those of the cross-section of the LC muscle in patients at rest and in contraction states were ICC=0.98 and ICC≥0.95, respectively (Table 4).

Discussion

The results indicated the excellent intra- and inter-tester reproducibility of the US procedure to measure the cross-section of the LC muscle due to the ICC value of >0.95. Intra-tester reproducibility was separately per-

Table 1. The Mean±SD of demographic features of healthy subjects and patients with neck pain

Groups	No.	Mean±SD			
		Age (y)	Height (cm)	Weight (kg)	Body Mass Index (kg/m²)
Healthy subjects	7	28±6.53	163.29±7.18	59.86±9.02	22.38±2.41
Patient subjects	7	32±8.28	160.14±7.96	60±9.30	23.07±1.49
P*	7	0.31	0.61	0.66	0.24

A significance level of <0.05.

Table 2. Intra-tester reproducibility of the cross-section of the LC in healthy subjects

Variables		Mean±SD		Pearsone's Coefficient	Cronbach's α	ICC	P	SEM	
		1st Reproducibility	2nd Reproducibility					1st Reproducibility	2nd Reproducibility
First tester	LCRR	0.98±0.2	0.98±0.2	0.98	0.99	0.99	0.000	0.09	0.09
	LCCR	1.20±0.3	1.18±0.3	0.98	0.99	0.99	0.000	0.11	0.12
	LCRL	1.00±0.2	1.00±0.2	0.97	0.98	0.98	0.000	0.08	0.08
	LCCL	1.14±0.2	1.12±0.2	0.96	0.98	0.98	0.000	0.07	0.08
Second tester	LCRR	0.98±0.2	0.97±0.2	0.96	0.97	0.97	0.000	0.11	0.11
	LCCR	1.18±0.3	1.18±0.3	0.99	0.99	0.99	0.000	0.11	0.11
	LCRL	1.00±0.2	1.01±0.2	0.99	0.99	0.99	0.000	0.08	0.08
	LCCL	1.13±0.2	1.11±0.2	0.99	0.99	0.99	0.000	0.08	0.08

PHYSICAL TREATMENTS

The intra-tester reproducibility of both Testers in the healthy group was excellent (ICC≥0.97).

Abbreviations: SEM: Standard error of measurement; ICC: Intraclass correlation of coefficient; LCRR: Longus colli cross-section area rest right; LCCR: Longus colli cross-section area contraction right; LCRL: Longus colli cross-section area rest left; LCCL: Longus colli cross-section area contraction left.

formed by two raters, and the results showed that each rater has excellent reproducibility.

Moreover, the reproducibility of the US method in healthy and patient subjects indicated that this imaging method was reliable for measuring the cross-section of the LC among patients with neck pain, as in healthy subjects. Therefore, the US can be used to evaluate and follow up the therapeutic interventions for patients with neck pain.

The reliability was achieved at rest and in contraction states; however, lower reliability was obtained in the contraction states than in the rest position.

Table 3. Intra-tester reproducibility of the cross-section of the LC in subjects with CNSNP

Variables		Mean±SD		Pearson's coefficient t	Cron-bach's α	ICC	P	SEM	
		1st Reproducibility	2nd Reproducibility					1st Repro-ducibility	2nd Reproducibility
1st tester	LCRR	0.90±0.2	0.87±0.2	0.97	0.98	0.98	0.000	0.11	0.09
	LCCR	1.12±0.2	1.09±0.3	0.90	0.95	0.95	0.001	0.10	0.11
	LCRL	0.91±0.3	0.90±0.3	0.96	0.98	0.98	0.000	0.13	0.12
	LCCL	1.00±0.3	1.01±0.3	0.95	0.97	0.97	0.000	0.13	0.14
2nd tester	LCRR	0.87±0.2	0.90±0.2	0.98	0.99	0.99	0.000	0.09	0.10
	LCCR	1.09±0.3	1.13±0.2	0.97	0.98	0.98	0.000	0.11	0.10
	LCRL	0.90±0.3	0.86±0.3	0.96	0.98	0.98	0.000	0.12	0.12
	LCCL	1.01±0.3	0.99±0.3	0.93	0.96	0.96	0.001	0.14	0.13

PHYSICAL TREATMENTS

The intra-tester reproducibility of both raters in the patient group was excellent (ICC≥0.95)

Abbreviations: CNSNP: Chronic non-specific neck pain; SEM: Standard error of measurement; ICC: Intraclass correlation of coefficient; LCRR: Longus colli cross-section area rest right; LCCR: Longus colli cross-section area contraction right; LCRL: Longus colli cross-section area rest left; LCCL: Longus colli cross-section area contraction left.

Table 4. Inter-tester reproducibility of the cross-section of the LC muscle

Variables		Mean±SD		Pearson's Coefficient	Cronbach's α	ICC	P	SEM	
		1st Reproducibility	2nd Reproducibility					1st Reproducibility	2nd Reproducibility
Healthy subjects	LCRR	0.98±0.2	0.98±0.2	0.98	0.99	0.99	0.000	0.09	0.11
	LCCR	1.20±0.3	1.18±0.3	0.99	0.99	0.99	0.000	0.11	0.11
	LCRL	1.00±0.2	1.00±0.2	0.98	0.99	0.99	0.000	0.08	0.08
	LCCL	1.14±0.2	1.13±0.2	0.94	0.97	0.97	0.000	0.07	0.08
Patients	LCRR	0.90±0.2	0.87±0.2	0.97	0.98	0.98	0.000	0.11	0.09
	LCCR	1.12±0.2	1.09±0.3	0.90	0.95	0.95	0.001	0.10	0.11
	LCRL	0.910.3 ±	0.90±0.3	0.96	0.98	0.98	0.000	0.13	0.12
	LCCL	1.00±0.3	1.01±0.3	0.95	0.97	0.97	0.000	0.13	40.1

PHYSICAL TREATMENTS

The inter-tester reproducibility of the healthy and patient groups was respectively obtained (ICC ≥0.97) and (ICC ≥0.95).

Abbreviations: SEM: Standard error of measurement; ICC: Intraclass correlation of coefficient; LCRR: Longus colli cross-section area rest right; LCCR: Longus colli cross-section area contraction right; LCRL: Longus colli cross-section area rest left; LCCL: Longus colli cross-section area contraction left.

The results of our study were consistent with the results of Jeong et al., who investigated the intra- and inter-tester reproducibility of the cross-section and thickness of the LC based on the degree of pressure applied to the ultrasound device probe (1-0.5) [19]. They found excellent intra- and inter-tester reproducibility. This study only examined reliability at the rest state while we investigated the reliability of the cross-section of the LC at rest and in contraction states. Thus, this proves that the present the protocol utilized in this study is trustworthy in healthy individuals and those with chronic neck pain.

Zargoosh et al. investigated the reliability of the US method on the cross-section of the LC and longus capitis muscles when taking the craniocervical flexion test on healthy subjects and patients with non-specific chronic pains in intra- and inter-day intervals [20]. They obtained an ICC of 0.91 from the cross-sectional measurement of healthy subjects while reporting an intra-day reliability value of 0.90 in the patient group versus values of 0.86-0.88 in the two groups, respectively [20]. The outcomes of their study confirm the claim that the US is the most reliable method to measure the cross-section of neck muscles.

Javanshir et al. showed within-day and between-day reproducibility of between 0.71 and 0.81 for individuals with mechanical neck pain. They stated that the ultrasound device was a valid instrument for patients with neck pain and healthy subjects [21]. Their results are consistent with the results of the current study.

O'Riordan et al. found "great" (intra-class correlation 0.90, 95% CI, 0.82%, 0.95%) and "moderate" (intra-class correlation 0.61, 95% CI, 0.37%, 0.77%) intra- and inter-tester reproducibility values, respectively, for ultrasound imaging of the LC cross-sectional area. They suggested that problems in the identification of boundaries of the LC muscle due to its profound anatomical position and environs structures made it hard for evaluators to agree favorably on cross-sectional area measurements, resulting in intermediate levels of inter-tester reproducibility. The excellent intra-tester reproducibility may indicate that the experience of the evaluator in using the ultrasound machine is of considerable importance [16]. In our study, excellent inter-tester reproducibility was obtained because both evaluators had the same experience. O'Riordan et al. concluded that the experience levels of users spanned from novice to skilled; however, all received some level of training in ultrasound imaging of the LC. The observed differences in results between this study and previous research may be due to differences in procedures of measurement, frequency used, and depth of field, as well as material used, including the type of probe [16].

Almeida et al. examined the intra- and inter-tester reproducibility of the cross-section of the LC muscle in women with migraines and a control group at rest and in contraction states [15]. The intra-tester reproducibility of the migraine group at rest and in contraction states was excellent and moderate in the right and left sides, re-

spectively. In the control group, the reproducibility was great (ICC=0.93) at the rest state and poor (ICC=0.35) in the contraction state. The inter-tester reproducibility was great (ICC>0.75) at rest on the right and left sides of both groups. The inter-tester reproducibility was intermediate (ICC=0.71) in the contraction state on the left side of the control group and great (ICC>0.75) in subsequent measurements.

Different results reported by Almeida et al. [15] can be due to the placement of the probe. They placed the probe parallel to the trachea while we placed the probe vertically to the neck pivot to better determine the range of the LC. Since the degree of contraction was not controlled in this study, the level of contraction may have been different during the imaging process. However, in the present study, the pressure biofeedback controlled the degree of contraction. For this reason, the contraction reliability was excellent.

Conclusion

US can be used as a tool to evaluate and follow up therapeutic interventions considering the excellent reliability of this technique in measuring the cross-section of the deep neck muscles. If special exercises or training lead to the hypertrophy of deep flexor muscles, their fascia layers are made clearer and the images will be better. Because this study only measured the cross-section of the LC muscle, future studies are suggested to measure the thickness and width of the muscle and to compare changes in the cross- section, thickness, and width of the muscle at rest and in contraction states.

Ethical Considerations

Compliance with ethical guidelines

This preliminary study was part of a main study entitled the effects of cervical mobilization techniques and neck stabilization exercises on the cross-section of neck deep flexor muscles and position sense in patients with (CNSNP), that was approved by Zahedan University of Medical Sciences (Code: IR.ZAUMS.REC.400.235). Informed consent was obtained from all participants.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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