

A novel instrument to examine the cervical range of motion of healthy Vietnamese adults

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Abstract:

This study aimed to evaluate a novel measurement instrument for recording cervical spine range of motion (ROM) in healthy Vietnamese adults at the Ho Chi Minh City Hospital for Rehabilitation - Occupational Diseases. A cross-sectional study was conducted from November 2023 to May 2024, involving 480 healthy volunteers aged 18-59 years who met the inclusion criteria. Their cervical ROM was measured in six directions (flexion, extension, left-side bending, right-side bending, left rotation and right rotation) using the novel measurement instrument (ROMIX). Data were analysed by age, gender, and measurement time. Statistically significant differences ($p < 0.05$) in ROM values were observed across age groups, indicating decreased ROM with increasing age. However, no significant differences ($p > 0.05$) were found between genders or measurement times. Thus, the novel instrument provides reliable ROM outcomes, highlighting age-related declines in normative ROM without gender- or time-related variations. This study has received support from Korea International Cooperation Agency (KOICA) under the project, conducted from 2024 to 2025 (Project No. 2021-00020-3).

Keywords: age, cervical, gender, healthy adults, measurement time, range of motion.

Classification numbers: 3.2, 3.6

1. Introduction

Cervical scapulothoracic syndrome, also known as cervical radiculopathy, is a cluster of clinical symptoms related to cervical spine pathologies, often involving dysfunction of cervical roots, spinal nerves, and/or the cervical cord [1]. Common symptoms include neck, shoulder, and arm pain, along with sensory disorders and reduced range of motion (ROM) in the neck. Musculoskeletal disorders with neck and shoulder pain, leading to disability and reduced labour force participation, are increasingly prevalent, particularly in middle- and low-income countries. This phenomenon poses a substantial economic and medical burden on communities, patients, families, and healthcare systems.

To address these challenges, this study introduces a novel measurement instrument utilising photogrammetry and computer vision to assess cervical ROM as a large-scale screening solution. The system employs four cameras to capture photogrammetric data from the patient's front, back, left, and right sides [2], allowing for the calculation of overlapping images and the construction of a three-dimensional (3D) representation of the human body. By recording patient movements in six directions - flexion,

extension, left side bending, right side bending, left rotation, and right rotation - the system determines movement angles and produces ROM measurement results.

Globally, ROM measurements have proven effective in identifying patients at risk of injury following trauma [3]. In Vietnam, however, diagnosis and evaluation of treatment efficacy often rely on manual methods, particularly goniometric measurements. Given the increasing prevalence of neck and shoulder conditions and their associated economic and healthcare burden, quick and accurate large-scale screening is essential. Therefore, this study aims to evaluate a novel photogrammetric instrument for recording cervical ROM in healthy Vietnamese adults, examining variations by age, gender, and measurement time.

2. Materials and methods

2.1. Study design

Participants aged 18-59 years, regardless of gender or occupation, were recruited. Inclusion criteria required participants to (1) engage regularly in study, work, and daily activities, (2) possess full cognitive and behavioural capacity, and (3) provide voluntary consent. Exclusion

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criteria included (1) reported or experienced neck, shoulder, or headache symptoms within the past month, (2) a history of neck or shoulder disorders (e.g., injuries, fractures, neurological or rheumatic conditions), and (3) other significant medical histories.

Participant selection adhered to the Military Medical Academy’s standards, including classification of normal ROM values and scoring based on the levels outlined in Table 1.

Table 1. Classification of cervical range of motion scores.

Range of motion level	Flexion/extension	Side bending/rotation	Score (point)
Normal	≥35°	≥40°	0
Mildly restricted	25°-34°	30°-39°	1
Moderately restricted	15°-24°	20°-29°	2
Severely restricted	<15°	<20°	3

The total score of six movements (flexion, extension, left side bending, right side bending, left rotation, right rotation) was used as the baseline for ROM assessment (Table 2).

Table 2. Assessment of cervical range of motion.

Range of motion level	Total score	Study score
Normal	0 point	0 point
Mildly restricted	1-6 points	1 point
Moderately restricted	7-12 points	2 points
Severely restricted	>12 points	3 points

The cross-sectional study was conducted from November 2023 to May 2024 at the Ho Chi Minh City Hospital for Rehabilitation - Occupational Diseases. Each participant’s measurement session lasted approximately 30 minutes (Table 3), yielding a total of 2 adults/hour × 6 hours/day × 5 days/week × 4 weeks/month × 2 months = 480 individuals. Background variables included age groups (20s: 18-29 years, 30s: 30-39 years, 40s: 40-49 years, 50s: 50-59 years) and gender (male/female), while the study variable was cervical spine ROM across six directions.

Table 3. Participant’s involvement in the study.

Task	Study explanation	Preparation	Data collection	Data interpretation	Extra time	Total
Time (min)	5	5	10	5	5	30

2.2. Instrument

The measurement instrument developed for this study utilised four cameras (Fig. 1) to capture spatial data from multiple angles (front, back, left, and right). Using photogrammetry, the technology creates a 3D image based on actual dimensions, providing accurate ROM measurements. Data were automatically uploaded to a secure database to ensure confidentiality.



Fig. 1. Range of motion measurement instrument.

Participants were instructed to stand at the centre of the instrument and perform maximum neck movements in six directions, holding each position for five seconds. Each movement was repeated three times, and the mean ROM and standard deviation were calculated.

2.3. Procedure (Fig. 2)

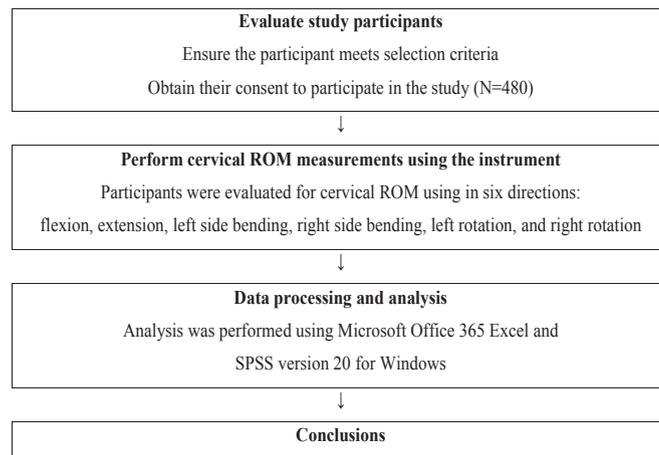


Fig. 2. Outline of study procedure.

2.4. Study ethics

This study was approved by the Medical Ethics Council of the University of Medicine and Pharmacy at Ho Chi Minh City under No. 704/HDDD-DHYD on July 27th, 2023 and the Medical Ethics Council of Ho Chi Minh City Hospital for Rehabilitation - Occupational Diseases under No. 17/HDDD-BVPHCN-DTBNN on November 1st, 2023. The study only aims to evaluate and improve patient health, not for any other purpose. All participants voluntarily engaged

in the study after receiving written consent and a thorough explanation of the study protocol. If any participant shows signs of non-cooperation or request to stop participating in the study, the study will discontinue their involvement.

3. Results and discussion

3.1. Results

As shown in Table 4, the data revealed a significant difference in cervical ROM across age groups, particularly in the extension movement. The ROM values decreased from $58.87 \pm 9.37^\circ$ in the 20s age group to $44.51 \pm 8.3^\circ$ in the 50s age group. This pattern highlights a decline in cervical mobility with age and underscores the need to understand age-related changes in assessing and treating cervical conditions. Additionally, statistical analysis revealed significant differences ($p < 0.05$) in ROM data across age groups when using the novel instrument.

Table 4. Cervical range of motion data by age group.

Mean±standard deviation (°)						
Age	Extension	Flexion	Left side bending	Right side bending	Left rotation	Right rotation
20s	58.87±9.37	78.65±10.42	56.23±7.44	51.61±7.47	74.55±8.04	77.82±6.43
30s	50.33±9.6	67.28±10.38	51.92±6.35	49.92±7.01	70.74±8.72	76.41±8.43
40s	45.65±8.1	64.91±9.82	48.21±7.64	45.28±8.23	65.07±9.44	73.65±9.51
50s	44.51±8.3	60.55±10.23	40.54±7.99	40.52±7.98	61.33±9.11	70.02±8.33
Overall population	49.8±10.0	67.84±10.21	49.44±7.35	41.85±7.67	67.90±8.82	74.48±8.18
p-value (one-way ANOVA)						
P ₂₀		P ₃₀				<0.05
	P ₄₀					<0.05
	P ₅₀					<0.05
P ₃₀		P ₄₀				<0.05
	P ₅₀					<0.05
P ₄₀		P ₅₀				<0.05

Regarding gender (Table 5), the mean ROM values for males and females in their 20s were similar, with slightly higher values observed in females. For example, males showed extension and flexion ROM of $58.54 \pm 10.0^\circ$ and $78.52 \pm 10.32^\circ$, respectively, while females exhibited $59.19 \pm 8.25^\circ$ and $79.17 \pm 9.25^\circ$, respectively. A consistent age-related decline in ROM values across all movements, with individuals in their 50s displaying the least ROM, at $45.31 \pm 8.76^\circ$ and $61.3 \pm 7.94^\circ$. A similar trend of decreasing ROM with age was also observed for females across all movements, which is highly consistent with the previous results of the age examination. However, no statistically significant differences ($p > 0.05$) in ROM were detected between males and females within the same age group.

Table 5. Cervical range of motion data by gender and age.

Mean±standard deviation (°)							
Gender	Age	Extension	Flexion	Left side bending	Right side bending	Left rotation	Right rotation
Male (n=241)	20s	58.54±10.0	78.52±10.32	56.54±8.45	51.54±7.68	74.85±9.32	77.9±8.53
	30s	49.91±8.32	66.91±8.65	50.91±8.29	48.79±7.65	70.4±8.87	75.84±7.36
	40s	44.24±8.51	64.42±8.49	47.46±8.03	44.56±7.93	64.79±8.65	72.48±8.68
	50s	43.31±7.22	59.34±8.19	40.23±7.88	40.5±7.12	60.86±8.49	69.57±7.65
Total		49.0±9.92	67.31±9.72	48.82±8.16	46.34±7.82	67.73±8.77	73.95±8.27
Female (n=239)	20s	59.19±8.25	79.17±9.25	57.19±8.97	51.85±8.16	74.54±9.21	78.25±8.21
	30s	51.39±8.89	68.39±8.46	52.39±7.62	49.94±7.52	70.84±8.72	77.12±8.59
	40s	46.42±9.15	65.18±8.92	49.87±7.48	45.71±7.49	65.51±9.01	73.56±7.98
	50s	45.31±8.76	61.3±7.94	41.82±7.33	41.65±7.06	61.58±8.15	71.04±8.33
Total		50.59±9.4	68.37±10.45	50.06±7.21	47.28±7.58	68.12±8.19	75.01±8.51
Overall population		49.8±10.0	67.84±10.21	49.44±7.35	46.81±7.67	67.82±8.82	74.48±8.18
p-value (paired t-test)		>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

For the measurement time, ROM data from the morning testing session for extension, flexion, left side bending, right side bending, left rotation, and right rotation were $50.77 \pm 9.41^\circ$, $68.02 \pm 10.56^\circ$, $40.02 \pm 6.89^\circ$, $41.42 \pm 7.42^\circ$, $67.73 \pm 8.75^\circ$, and $73.95 \pm 8.27^\circ$, respectively. As shown in Table 6, during the afternoon session, the mean values for these movements were slightly lower, yielding 48.65° , 67.66° , 40.42° , 42.28° , 66.83° , and 75.01° , respectively. It is also noteworthy that no statistically significant differences ($p > 0.05$) were observed between the two measurement times.

Table 6. Cervical range of motion data by measurement time.

Mean±standard deviation (°)							
Session	Extension	Flexion	Left side bending	Right side bending	Left rotation	Right rotation	p-value (paired t-test)
Morning	50.77±9.41	68.02±10.56	40.02±6.89	41.42±7.42	67.73±8.75	73.95±8.27	0.92
Afternoon	48.65±9.07	67.66±10.13	40.42±7.55	42.28±7.18	66.83±8.52	75.01±8.51	

3.2. Discussion

The study included 480 healthy Vietnamese adults (241 males and 239 females) to evaluate cervical ROM using a novel instrument. Measurements were taken across six directions: flexion, extension, left and right side bending, and left and right rotation. The findings aligned with previous studies [4], demonstrating a gradual decline in cervical ROM with age, particularly in flexion and extension, where average reductions of 5° were noted. Bilateral side bending and rotation showed smaller decreases ($\sim 3^\circ$), consistent with J.W. Youdas, et al. (1992) [5].

Statistically significant differences in ROM data between age groups ($p < 0.05$) were observed, signifying a declining ROM with age, which may be attributed to the physiological increase in thoracic kyphosis angle as individuals grow older.

Consequently, the cervical vertebrae adapt by increasing their lordosis to maintain spinal function, resulting in a more substantial decrease in flexion and extension mobility compared to side bending and rotation movements. Such phenomenon is consistent with reported findings [6], attributing the decrease in ROM to physiological spinal degeneration and changes in intervertebral and cranial arch angles. Moreover, K.A. Alahmari, et al. (2017) [7] in examining cervical ROM across planes demonstrated that ROM reduction was greater in the sagittal plane (flexion and extension) compared with the frontal and transverse planes (side bending and rotation). While cervical mobility tends to be higher in females, no statistically significant differences ($p>0.05$) were found between gender, which is in good agreement with R.A.H.M. Swinkels, et al. (2014) [4]. Greater ROM values in females is typically ascribed to higher flexibility due to the influence of oestrogen on water retention and muscle relaxation, leading to increased joint mobility and wider ROM. Additionally, the use of the novel instrument to record cervical ROM over time further aligns with previous studies with no statistically significant differences ($p>0.05$) between the testing sessions.

As a result, the novel photogrammetric instrument developed in this study can have significant clinical applications through accurate and reliable ROM measurements for individuals with a risk of cervical pathologies. The instrument can also be employed in rehabilitation settings to monitor patient progress and treatment response, thereby supporting recovery and treatment outcomes. Besides, the obtained ROM baseline data for different age groups and gender can be used for comparison with healthy standards to evaluate patient condition.

The authors acknowledge that longitudinal studies over a more diverse sample, including the impact of additional neck movement directions and other factors on gender differences, could improve the generalisability of the results. Expanding the study to a population with cervical pathologies and other musculoskeletal disorders could further validate the instrument's utility and broaden its clinical applicability.

4. Conclusions

In this study, a novel instrument was introduced to measure the cervical ROM of 480 healthy Vietnamese adults across different age groups, gender, and measurement times. The obtained results are similar to previous studies, concluding that cervical ROM declines with age, with decreasing cervical mobility of the elderly. This reduction can be associated with physiological changes such as an increase in thoracic kyphosis angle and spinal degeneration. The flexion and extension directions tend to decrease more rapidly than the bilateral side bending and rotation. Meanwhile, gender and measurement time did not significantly influence cervical ROM values, showing no statistically significant differences ($p>0.05$). Regardless, females typically demonstrate a higher

cervical ROM than their male counterparts across all age groups. Such flexibility in females may be linked to higher oestrogen levels, which contribute to improved joint mobility and ROM. The attained results emphasise the importance of understanding how different factors in cervical ROM affect the evaluation and treatment of spinal health, facilitating better healthcare for musculoskeletal disorders.

CRedit author statement

Nguyen Huu Duc Minh: Methodology, Investigation, Writing - Reviewing and Editing; Nguyen Minh Hoai: Investigation, Formal analysis; Che Quang Cong: Data curation, Writing - Original draft preparation; Pham Le An: Conceptualisation, Supervision; Chau Duc Hoa: Visualisation, Writing - Original draft preparation.

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COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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