SURVEY OF NECK RANGE OF MOTION USING SYSTEM WITH SENSOR-INTEGRATED BASED ON PHOTOMETRY METHOD AND ZERO METHOD ON HEALTHY VOLUNTEERS

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ABSTRACT

Objective: The study aimed to evaluate the accuracy and reliability and of the system with sensor-integrated based on photometry method (PMD-HAM system) compared with the Zero method using a goniometry when measuring the range of motion of the neck joints of healthy volunteers at the Ho Chi Minh City Hospital for Rehabilitation and Occupational Diseases.

Method: Conducted over four months at the Hospital for Rehabilitation – Occupational Diseases, the research included 50 healthy volunteers (24 males, 26 females) with strict inclusion and exclusion criteria. Both conventional goniometry and the system with sensor-integrated based on photometry method were utilized to assess cervical range of motion (ROM) across six movements: flexion, extension, right lateral flexion, left lateral flexion, right rotation, and left rotation.

Results: Results indicated no statistically significant differences between the measurements obtained using both methods ($p > 0.05$). These findings suggest that the system with sensor-integrated based on photometry method is a reliable and valid alternative to traditional measurement techniques for assessing cervical ROM.

Conclusion: The implementation of this innovative method may enhance routine clinical assessments, promote accurate data collection in diverse settings. Future research will involve a more varied participant demographic and refined measurement apparatus to further validate the method's efficacy.

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I. INTRODUCTION

Cervical radiculopathy (CR) is a group of clinical symptoms associated with cervical spine pathologies that are accompanied by dysfunction of the cervical roots, spinal nerves and/or cervical spine. Common symptoms include pain in the neck, shoulder, and arm, accompanied by some sensory disorders and/or reduced range of motion in the cervical area. CR with cervical pain, shoulder pain in the population commonly has complications of disability and loss of working ability, especially patients in low-income countries. This is an economic and medical burden for the entire world in general, individual patients and families, communities, and medical forces [1].

The range of motion method (ROM) has been proved to be able to classify initially patients at risk of injury after sudden trauma [2]. In Vietnam, the diagnosis and evaluation of the effectiveness of the treatment is ROM manual method (traditional goniometer). Although the availability has been proved, these instruments require the assistance of skilled operators therefore, the device is cumbersome and requires manual reading.

Photogrammetry is another noninvasive technique and has been widely applied to in cervical measurement [3–6]. However, the preparatory work of photogrammetry is relatively tedious due to the placement of cameras and body markers. Considering the advantages of the photogrammetry we developed an innovative technique for the measurement of Cervical ROM based on it. This approach is reliable, automatic and convenient for people with or without relevant medical knowledge. As a result, this study is intended to evaluate the accuracy and reliability of this new technique for measuring cervical ROM compared to traditional goniometry.

Objective:

1. Compare the results of measuring the range of neck motion (flexion - extension, right lateral flexion - left lateral flexion, right rotation - left rotation) using a body ROM measuring device.

2. Compare the results of measuring the range of neck motion (flexion - extension, right lateral flexion - left lateral flexion, right rotation - left rotation) between researcher 1 and researcher 2 using the body ROM measuring device.

II. SUBJECTS AND METHODS

2.1. Subjects, location and duration

- Duration: April 2024 to August 2024.

- Location: Hospital for Rehabilitation - Professional Diseases, 313 Au Duong Lan street, Ward 2, District 8, Ho Chi Minh City.

- Subject:

Inclusion criteria

+ Participants must be at least 18 years old, regardless of gender or occupation.

+ People who study, work and normal activities.

+ Participants voluntarily agree to participate in the study.

Exclusion criteria

+ Study participants reported or complained of neck, shoulder and/or headache pain in 30 days before.

+ People with a history of neck and/or shoulder disorders, including injuries and fractures, a history of neurological and/or rheumatic disorders.

Healthy volunteer criteria:

Age: 18 years or older

No significant medical history: Free from any chronic or acute illnesses, including but not limited to:Cardiovascular diseases (e.g., heart failure, coronary artery disease);Respiratory diseases (e.g., asthma, COPD);Neurological disorders (e.g., epilepsy, multiple sclerosis);Endocrine disorders (e.g., diabetes, uncontrolled thyroid disease);Autoimmune diseases (e.g., rheumatoid arthritis, lupus);Cancer;Mental health disorders (e.g., severe depression, schizophrenia);Infectious diseases (e.g., HIV, hepatitis);Kidney or liver diseases

2.2. Methods

Research design

Cross-sectional study

Sample size

A prior sample size calculation is based on the methods of Walter et al. [7], assuming significance level (α) = 0.05, type II error probability (β) = 0.2, confidence level Minimum acceptable reliability (ρ0) = 0.7 and expected reliability (ρ1) = 0.9, and n = 2; Anticipating a 10% sample loss, a sample size of 50 participants would be required.

p0	p1								
	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9
n = 2									
0	651·6	151·9	70·0	35·9	22·0	14·4	9·7	6·6	4·4
0·1		591·2	142·8	60·6	32·2	19·1	12·0	7·7	4·8
0·2			543·7	128·2	53·0	27·2	15·5	9·2	5·3
0·3				476·2	109·0	43·5	21·4	11·4	6·1
0·4					393·1	86·6	32·9	15·1	7·1
0·5						300·3	62·6	22·0	8·8
0·6							205·4	39·1	11·7
0·7								117·1	18·4
0·8									45·8

Variables

- Background variables:

+ Age: year of study minus year of birth;

+ Gender: Male/Female.

- Research variables:

Range of motion (ROM)	Quantitative variable	**Attaching a coordinate system Oxyz to** The origin O is at the midpoint of the spinous process of the C7 vertebra. Ox: right-left axis Oy: bottom-top axis Oz: back-front axis **Identify the points to be measured:** C: Vertex of the head (point of intersection between two lines: one line passing horizontally through the top of the ear and one line passing vertically through the center of the head). E: Vertex of the nose. **Convention for the measured variables** **Researcher measures** ROM for flexion-extension (View from the side): EOy when bending forward and backward. ROM for lateral bending (View from behind): COy when bending left and right. ROM for rotation (View from above): EOz when rotating left and right. **Measuring device** ROM for flexion-extension (View from the side - Oyz plane): EOy when bending forward and backward. ROM for lateral bending (View from behind - Oxy plane): COy when bending left and right. ROM for rotation (View from above - Oxz plane): EOz when rotating left and right.

Measurement and data collection tools

- A goniometer used for measuring of joint range of motion has calibration certificate No. KT3-00481ADD4 on April 11, 2024.

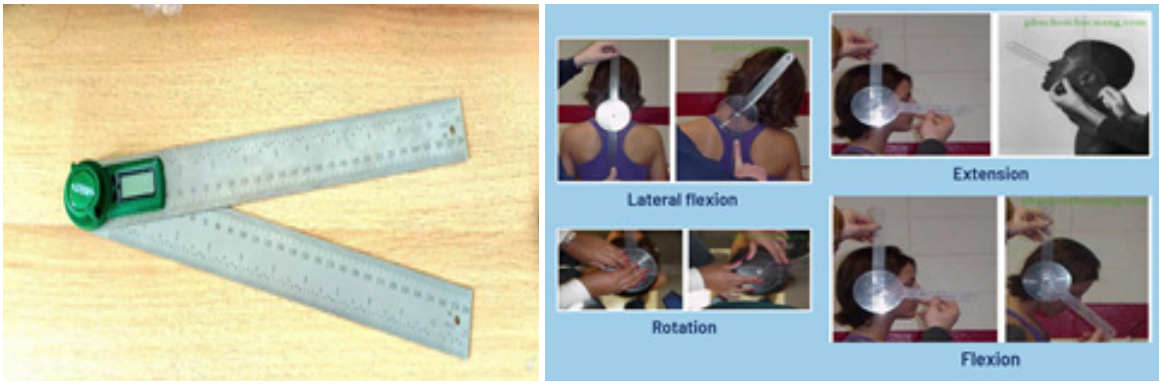


Figure 1. Goniometer

- ROMIX photogrammetric instrument has been standardized at the Ho Chi Minh City Quality Measurement Standards Technical Center under No. 0832TN22/TĐC – TN on October 28, 2023.

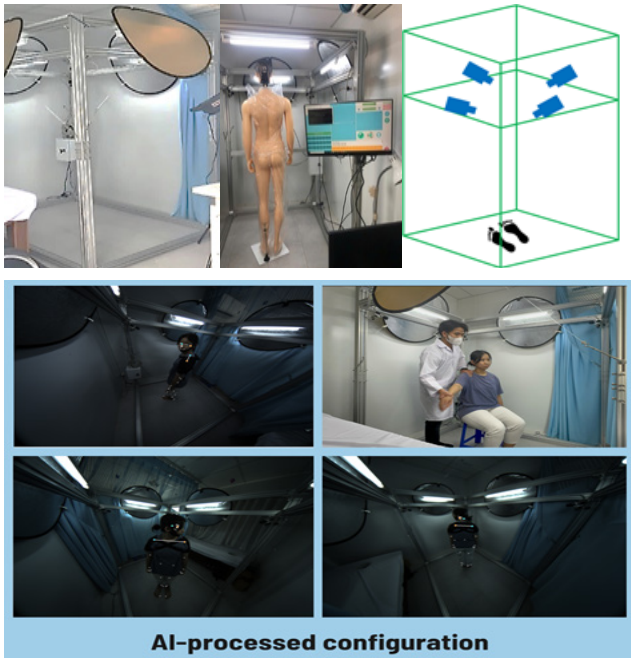


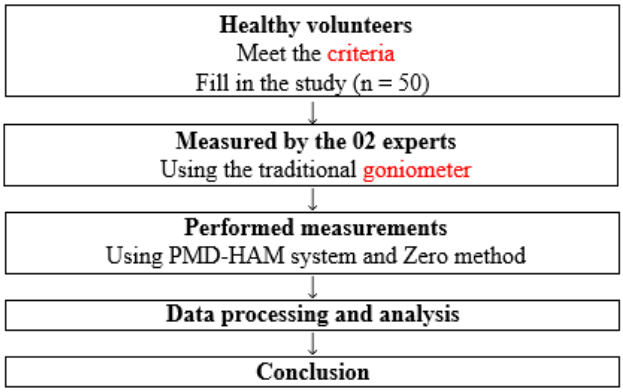
Figure 2. PMD- HAM systems

Photometric Machine

The participants' cervical ROM were measured using the photometric machine.

All images from the machine and the results from the researchers were transferred to a computer for analysis.

Procedure



Statistical methods – data processing

Data collected was processed according to medical statistical algorithms of SPSS 25 software. Compare average ± standard deviation by using one-way ANOVA test.

2.3. Research ethics

- Research is only to evaluate and improve volunteers' health, not for any other purpose. Research participants volunteered to participate after the research process was clearly explained.

- Monitor and evaluate the condition of study participants after 1 month. If the volunteer develops any unpleasant health symptoms caused by the research methods of this study, the researcher will be responsible for consultation and treatment.

- When research participants show signs of not cooperating further or request to stop participating in the research, the research will be stopped.

- Evaluation of research participants' results is done objectively and honestly in data processing.

III. RESULTS

The mean of all six cervical movements from researcher 1, researcher 2 and the photogrammetry are depicted in Table 1. The results of measuring the Cervical ROM of all six cervical movements between researcher 1, researcher 2 and the Photogrammetry machine do not change statistically significantly ($p > 0.05$) (Table 2).

Table 1. Cervical range of motion from researcher 1 and PMD-HAM system

		Researcher 1			PMD-HAM system		
		Range (°)	Mean (°)	Standard deviation (°)	Range (°)	Mean (°)	Standard deviation (°)
Flexion	Male	34-60	45.7	6.88	32-58	44.99	6.07
	Female	32-71	48.24	10.45	34-72	48.19	10.12
Extension	Male	31-43	35.76	4.03	29-43	34.32	4.46
	Female	29-49	37.74	6.01	31-48	38.13	5.27
Right lateral flexion	Male	31-53	42.18	4.94	36-54	43.04	4.49
	Female	34-50	42.06	5.03	32-55	44.11	5.23

		Researcher 1			PMD-HAM system		
		Range (°)	Mean (°)	Standard deviation (°)	Range (°)	Mean (°)	Standard deviation (°)
Left lateral flexion	Male	32-52	40.07	4.57	30-52	40,37	4.62
	Female	34-53	43.23	5.74	33-53	42.62	5.04
Right rotation	Male	55-84	74.02	6.18	56-85	74.16	6.44
	Female	65-83	75.71	5.27	65-85	77.95	5.86
Left rotation	Male	55-86	71.15	6.82	55-83	71.60	6.84
	Female	63-84	72.71	5.16	64-84	74.98	5.45

Table 2. Cervical range of motion from researcher 2 and PMD-HAM system

		Researcher 2			PMD-HAM system		
		Range (°)	Mean (°)	Standard deviation (°)	Range (°)	Mean (°)	Standard deviation (°)
Flexion	Male	33-60	45.86	7.02	32-58	44.99	6.07
	Female	34-72	47.04	9.67	34-72	48.19	10.12
Extension	Male	30-44	35.1	3.92	29-43	34.32	4.46
	Female	30-50	38.01	5.98	31-48	38.13	5.27
Right lateral flexion	Male	33-54	41.87	5.07	36-54	43.04	4.49
	Female	33-52	43.19	5.24	32-55	44.11	5.23
Left lateral flexion	Male	30-49	40.12	4.19	30-52	40.37	4.62
	Female	33-53	43.24	5.13	33-53	42.62	5.04
Right rotation	Male	57-89	74.27	6.24	56-85	74.16	6.44
	Female	63-91	74.37	6.98	65-85	77.95	5.86
Left rotation	Male	53-86	70.25	7.30	55-83	71.60	6.84
	Female	64-87	75.43	5.32	64-84	74.98	5.45

Table 3. Comparison of CROM between two researchers using One-Way Anova

Position	Researcher	p
Flexion	Researcher 1	0.782
	Researcher 2	
Extension	Researcher 1	0.795
	Researcher 2	
Right lateral flexion	Researcher 1	0.783
	Researcher 2	
Left lateral flexion	Researcher 1	0.715
	Researcher 2	
Right rotation	Researcher 1	0.687
	Researcher 2	
Left rotation	Researcher 1	0.822
	Researcher 2	

Table 4. Comparison of flexion and extension from PMD-HAM system using One-Way Anova

Position	CROM		p
Flexion	Time 1	Time 2	0.776
		Time 3	0.812
	Time 2	Time 3	0.795

Position	CROM		p
Extension	Time 1	Time 2	0.787
		Time 3	0.654
	Time 2	Time 3	0.834

Table 5. Comparison of right, left lateral flexion from PMD-HAM system using One-Way Anova

Position	CROM		p
Right lateral flexion	Time 1	Time 2	0.823
		Time 3	0.706
	Time 2	Time 3	0.845
Left lateral flexion	Time 1	Time 2	0.876
		Time 3	0.687
	Time 2	Time 3	0.833

Table 6. Comparison of right and left rotation from PMD-HAM system using One-Way Anova

Position	CROM		p
Right rotation	Time 1	Time 2	0.745
		Time 3	0.587
	Time 2	Time 3	0.712
Left rotation	Time 1	Time 2	0.734
		Time 3	0.507
	Time 2	Time 3	0.737

IV. DISCUSSION

Our research was carried out on 50 healthy vonlunteers consisting of 24 males and 26 females, who were assessed the ROM on the six neck movements. ROM of neck flexion and extension measured by the two researchers and the machine are compatible to those in the research of Green and Heckman 1994 [7], which is 45° in flexion and 38° in extension. ROM of neck lateral flexion measured by the two researchers and the machine are compatible to those in the research of American Medical Association 1998 [9], which is 45° in the right and 38° in the left side. ROM of neck rotation measured by the two researchers and the machine are compatible to those in the research of Green and Heckman 1994 [7], which is 45° on both sides. We can see that in researches with different sample sizes, volunteers' statistics and geography, the ROM may vary between ages and sexes. Therefore, tools and equipment used in the research play an important role. The Zero method we use in the research has been approved by the American Plastic Surgery Conference and the Vancouver Conference in 1964 [11] since 1964 and the traditional goniometer in Ho Huu Luong's research [12], which have been standardized and highly reliable.

This study developed a novel photogrammetric method for the measurement of 3D ROM. The mean of range of this method was investigated by comparing it with the goniometer- based method. The One way – Anova analysis showed there was no significant difference between ($p > 0.05$) the new method and the goniometer based method for all six cervical movements. Besides, our method is relatively affordable for routine examinations. As for the traditional measurement tools like the goniometer, using these tools requires the assistance of an operator with relevant medical knowledge, and the operation of measuring and data reading is completely manual, which may introduce random error. Our method, on the contrary, can record and analyze the Cervical ROM regardless of the position and posture of the neck in 3D space, and the whole procedure is done automatically by program, which is more correct and reliable. In addition, our team is applying a

sensor device that applies the Euler angle principle to the measurement method to further standardize the measuring machine, with the goal of optimizing the process of measuring the range of motion of the neck joint, applied in collecting biometric data as well as helping in the clinical practice of neck diseases.

V. CONCLUSION

The performance of the proposed photogrammetric method for the measurement of 3D CROM was deeply analyzed by comparison with other approaches, and results showed excellent consistency and reliability. This shows that the measurements, when repeated, are not biased parameters, and at the same time reliable when the operator performs operations according to standardized measurement procedures. Based on this technique, a Cervical ROM historical database could be set up to better check the changes of Cervical ROM. In the future work, a more diverse group of subjects including healthy and unhealthy people will be involved, and a more precise device will be used as a synchronous reference of the proposed method. In-depth research will also be conducted on pattern analysis of cervical motion curves, to consider its relevant wellness management applications in clinical and home applications.

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