

# Agreement and reliability of two non-invasive methods for assessing cervical range of motion among young adults

Concordância e confiabilidade de dois métodos não-invasivos para a avaliação da amplitude de movimento cervical em adultos jovens

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## Abstract

**Background:** Cervical range of motion (CROM) is a fundamental component of the functional evaluation in physical therapy interventions. The CROM device stands out as a reliable, non-invasive and easy-to-use method, but it is a very expensive tool. In clinical practice, more affordable tools such as Fleximeters are preferred. However, the reliability of Fleximeters for the cervical spine has not been adequately tested. **Objectives:** To compare the Fleximeters and the CROM device for the analysis of CROM, and to investigate the intra- and inter-examiner reliability of both tools. **Methods:** Cervical movements (flexion, extension, lateral flexion and rotation) were assessed in 20 asymptomatic young women by three examiners using both tools. The statistical analyses were performed using the intra-class correlation coefficient (ICC). **Results:** The agreement between the tools was considered moderate for flexion and left rotation (0.71; 0.58) and excellent for all of the other movements (0.76-0.87). The intra-examiner reliability for the CROM device was moderate for flexion and right rotation (0.70; 0.69) and excellent for all of the other movements (0.79-0.88). For the Fleximeter, the agreement was excellent for inclination and right rotation (0.80; 0.77) and moderate for all of the other movements (0.69-0.75). The inter-examiner reliability for the CROM device was excellent for all movements (0.76-0.93) and for the Fleximeter, it was moderate for right and left rotation (0.66; 0.75) and excellent for all of the other movements (0.81-0.88). **Conclusions:** There was agreement between the CROM assessments using the Fleximeter and the CROM device. Furthermore, both devices showed acceptable reliability for clinical practice.

**Key words:** cervical range of motion; assessment; reliability; CROM; Fleximeter.

## Resumo

**Contextualização:** A amplitude de movimento (ADM) cervical é fundamental na avaliação funcional e na intervenção fisioterapêutica. O *Cervical Range of Motion* (CROM) destaca-se por ser um método confiável, não invasivo e de fácil manuseio, porém de alto custo. Na prática clínica, opta-se por aparelhos mais acessíveis, como o Flexímetro, cuja confiabilidade ainda não foi adequadamente testada para o segmento cervical. **Objetivos:** Comparar o Flexímetro com o CROM na análise da ADM cervical e verificar a confiabilidade intra e interexaminadores de ambas as ferramentas. **Métodos:** Os movimentos cervicais de flexão, extensão, inclinação lateral e rotação foram mensurados, com ambas as ferramentas, por três examinadores em 20 indivíduos jovens, do sexo feminino, assintomáticos. A análise estatística foi realizada pelo Coeficiente de Correlação Intraclasse (ICC). **Resultados:** A concordância entre as ferramentas foi considerada moderada nos movimentos de flexão e rotação esquerda (0,71;0,58) e excelente nos demais movimentos (0,76-0,87). A confiabilidade intraexaminadores com o CROM foi moderada para os movimentos de flexão e rotação direita (0,70; 0,69) e excelente para os demais movimentos (0,79-0,88); com o Flexímetro, foi excelente para inclinação e rotação direita (0,80; 0,77) e moderada para os demais movimentos (0,69-0,75). A confiabilidade interexaminadores com o CROM foi excelente em todos os movimentos (0,76-0,93) e, com o Flexímetro, foi moderada para os movimentos de rotação direita e esquerda (0,66; 0,75) e excelente para os demais movimentos (0,81-0,88). **Conclusões:** Os valores obtidos na avaliação da ADM cervical feita pelo Flexímetro concordam com aqueles mensurados pelo CROM. Além disso, ambas as ferramentas apresentam confiabilidades aceitáveis para a prática clínica.

**Palavras-chave:** ADM cervical; avaliação; confiabilidade; CROM; flexímetro.

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## Introduction

The evaluation of the cervical range of motion (CROM), much used in physical therapy practice<sup>1</sup> is an important device for diagnosing musculo-skeletal disorders<sup>2</sup>, to analyze the progression of diseases<sup>3</sup>, to evaluate the effects of different treatments<sup>4</sup> and to monitor the progress of patients during rehabilitation<sup>1, 5-7</sup>. The limitations of cervical Range of Movements (ROM) may indicate musculoskeletal disorders, neck pain resulting from trauma or idiopathic<sup>8,9</sup>, headaches<sup>8,10-12</sup> or some dysfunctions in the temporo-mandibular joints and masticatory muscles<sup>12-14</sup>.

During the analysis of ROM, one should consider the existence of natural variations between individuals, as well as factors which influence this variability, such as gender, age and the nature of movements, either passive or active<sup>1</sup>. For example, women have greater movement amplitudes in relation to men<sup>12,15-19</sup>, and aging leads to less ROM<sup>13,19-21</sup> for about five degrees per decade<sup>22</sup>.

There is a need to obtain quantitative, objective and reliable measures for physical therapy evaluation. However, the cervical spine shows more complexity due to the associated movements of the high thoracic spine and shoulders<sup>12,13</sup> and the lack of precise anatomical marks in this region<sup>18,23</sup>.

To accurately measure the ROM, it is essential that it is evaluated by reliable methods and tools, non-invasive and which can be used by different examiners<sup>2,24</sup>; in addition, it is desirable that it be easy to use and provides clinically accurate and significant data<sup>1,25</sup>.

Despite the diversity of instruments cited in the literature for the evaluation of the ROM, there is no consensus among professionals as to which method would be most indicated<sup>8,11,26</sup> and which protocol should be followed<sup>8</sup>. The method considered the gold standard in the literature is the radiograph, however, it is an impractical tool for the clinical use; considering the need for reevaluation, it might result in excessive exposure of patients to radiation and constant costs for patients and health services<sup>15,25,27,28</sup>.

There are a variety of available non-invasive methods, such as visual estimations, the goniometer, the inclinometer, the potentiometer, compasses, videos and electromagnetic technologies. However, for most of them, the intra- and inter-examiner reproducibility were not properly evaluated<sup>29</sup>.

The Cervical Range of Motion device (CROM) is a goniometer capable of measuring the ROM of flexion, extension, inclination and rotation of the cervical spine by three inclinometers<sup>30</sup>. It has the advantage of recording in all planes without the need for anatomical markers and

the repositioning of the device throughout the assessments<sup>31</sup>. Tousignant et al.<sup>7,18,31</sup> assured the validation of this instrument in symptomatic and asymptomatic patients, compared it with the radiographic techniques<sup>7,18</sup> in the movements of flexion/extension and inclination and with OPTOTRAK<sup>31</sup> (non-invasive system for measurements using the incidence of infrared light) in the rotation movements, and found excellent reliability indices (0,82-0,98).

Youdas Carey and Garret<sup>32</sup> showed the index of intra-class correlation coefficients (ICC) ranging from 0.73 to 0.95 in symptomatic groups and similar data were found by Capuano-Pucci et al.<sup>33</sup> in asymptomatic groups. Bevilaqua-Grossi et al.<sup>10</sup> evaluated a female population with migraines and reported an intra-examiner reliability ranging from 0.79 to 0.99 and inter-examiner reliabilities ranging from 0.68 to 0.95. Unlike other instruments, it is a method whose reliability is well established in the literature, since several studies have demonstrated ICC ranging from good to excellent<sup>7,10,18,29-33</sup>. However, the CROM is less used because it is an imported equipment with a high cost.

The device most commonly used in physical therapy practice is the Fleximeter, a goniometer gravity-dependent instrument of low-cost and easy to use, which evaluates ROM of several joint. Its reliability for the evaluation of cervical ROM has not been fully established. Lima et al.<sup>34</sup> evaluated only two movements of the cervical spine and demonstrated excellent ICC values (0.79) and moderate (0.55) for rotations and inclinations, respectively. There were not found in the literature, studies which compared this instrument with another techniques of cervical ROM evaluations.

The present hypothesis is that the Fleximeter is able to reproduce the values obtained by CROM, which would indicate that this tool would be reliable for clinical practice. Therefore, the objectives were to verify the correlations between cervical ROM measurements obtained with the CROM and with the Fleximeter and, additionally, to verify the intra- and inter-examiner reliability of both tools.

## Methods

Randomly, 20 asymptomatic women subjects, with a mean age of 22 years ( $\pm 2$ ), were evaluated. The three examiners in the study were previously trained in each technique for a period of six hours per week for two weeks.

The exclusion criteria were to be younger than 18 years and demonstrate a history of trauma, surgery or any other dysfunctions of the cervical region. The subjects were

instructed to sit with their feet flat on the floor, with their knees and ankles at 90° of flexion, support their hands on their thighs and stay in a relaxed position, which was considered the starting position for the individual. Then, familiarization training was performed to demonstrate the equipment and the instructions to the subjects about the compensatory movements which were corrected during the active performance of the six measured movements (flexion, extension, right lateral inclination, left lateral inclination, right rotation and left rotation).

The devices used were the CROM (Figure 1) and the Fleximeter (Figure 2). The first, developed by Performance Attainment Associates (Roseville, MN), measured the ROM of flexion, extension, lateral inclination and rotation of the cervical spine by three inclinometers, whose scales ranged from two to two degrees. These inclinometers are attached to a frame similar to glasses: one, in the frontal plane, to lateral inclination; another, in the sagittal plane, to flexion/extension and the third, in the transverse plane, for rotation. Two of them were gravity-dependent (the frontal and sagittal) and the transverse one was magnetic dependent. A magnetic necklace was placed on the subject to measure the rotation<sup>20</sup>.

The fleximeter, developed and manufactured in Brazil, patented at the Code Institute of Research<sup>34</sup>, consisted of a gravity-dependent inclinometer, whose the scale was of one grade, attached by a velcro tape. At the end of each movement, the device was repositioned. All movements were measured with the subjects seated, except for the movements of rotation, in which they had to stay in the supine position, with their shoulders aligned with the end of the apparatus. So that the individuals would not be insecure, the examiner placed a supporting hand on the occipital region, but did not interfere with the active movement of the subject<sup>34</sup>. This exception was done to maintain the position of the device favorably for the effects of gravity.

The movements of flexion, extension, lateral inclination and rotation were evaluated by three different examiners with the CROM and with the Fleximeter, randomized to a number sequences selected by the subjects. For each movement, three repetitions were made, from which the average obtained. There was no interval between assessments. The whole procedure described above was repeated at a one week interval to test the intra-examiner reliability.

All procedures in this study were approved by the Committee of Ethics in Research of the Clinics Hospital of Ribeirão Preto and the Faculty of Medicine of Ribeirão Preto, according to opinion number 5230/2008 and all subjects signed a consent form.



**Figure 1.** Cervical Range of Motion (CROM, Performance Attainment Associates, St. Paul, MN, USA) in the frontal (A) and sagittal (B) planes.



**Figure 2.** Fleximeter (ICP) in the frontal (A) and sagittal (B) planes.

## Statistical analyses

The comparisons between the two methods was made by the ICC, which verified the degrees of correlations between the measures for each class<sup>35</sup>. The closer the coefficient was to 1, the higher was the correlation. The agreement between the tools was classified, in accordance with ICC values, as poor (<0.4), moderate (0.4-0.75) or excellent (>0.75)<sup>36</sup>. The confidence interval used was 95%.

For each tool, there were also obtained the intra- and inter-examiner reliabilities by ICC using SPSS 10.0 for Windows. For the calculation of reliabilities, the average of the three measurements taken for each movement during the evaluation was used. The intra-examiner reliability measures, the accuracy of a device when used more than once by the same examiner, as the ideal tool should not provide different results if the ROM, in fact, has not changed<sup>37</sup>. The inter-examiner reliability measured the accuracy of the method when it is used in the same situation by different examiners, as the result of the tool, should not vary from observer to observer<sup>37</sup>. The classification of reliabilities should be the same used in the comparisons of the tools described above.

## Results

### Concordance between the measurements obtained with the CROM and with the Fleximeter

The ICC values were 0.82; 0.71; 0.87; 0.83; 0.76; and 0.58 for the movements of extension, flexion, right lateral inclination, left lateral inclination, right rotation and left

**Table 1.** Comparisons between the two devices using St. Laurent's coefficient.

Movement	ICC n=20	Standard error	95% Confidence interval	
			Lower	Upper
Extension	0.56	0.06	0.47	0.65
Flexion	0.61	0.08	0.52	0.70
Right lateral flexion	0.75	0.04	0.69	0.80
Left lateral flexion	0.49	0.05	0.40	0.59
Right rotation	0.53	0.07	0.41	0.65
Left rotation	0.44	0.10	0.36	0.54

ICC=intra-class correlation coefficient.

rotation, respectively (Table 1). These values indicated an excellent agreement for most of the movements, except for flexion and left rotation, which showed moderate agreement.

### Intra- and inter-examiner reliability

The intra-examiner reliability of the values obtained with the CROM was excellent for the movements of extension, right lateral inclination, left lateral inclination and left rotation and moderate for flexion and right rotation (Table 2). For the values obtained with the Fleximeter, the intra-examiner reliability was excellent for the movements of the right lateral inclinations, and right rotations, and moderate for the other assessed neck movements (Table 2).

In the inter-examiner reliability of the values obtained with the CROM, there were excellent values for all assessed cervical movements (Table 3). For the values obtained with the Fleximeter, the inter-examiner reliabilities were

**Table 2.** Intra-examiner reliability assessed by the Intraclass Correlation Coefficient (ICC).

Device	Movement	ICC/intra n=20	Standard error	95% Confidence interval	
				Lower	Upper
CROM	Extension	0.81	0.06	0.69	0.92
	Flexion	0.70	0.08	0.55	0.86
	Right lateral flexion	0.88	0.04	0.80	0.95
	Left lateral flexion	0.81	0.06	0.69	0.92
	Right rotation	0.69	0.08	0.53	0.85
	Left rotation	0.79	0.06	0.67	0.91
Fleximeter	Extension	0.75	0.07	0.61	0.89
	Flexion	0.69	0.08	0.54	0.85
	Right lateral flexion	0.80	0.06	0.69	0.92
	Left lateral flexion	0.72	0.08	0.57	0.87
	Right rotation	0.77	0.07	0.64	0.90
	Left rotation	0.69	0.08	0.53	0.85

CROM=cervical range of motion.

**Table 3.** Inter-examiner reliability assessed by the Intraclass Correlation Coefficients (ICC).

Device	Movement	ICC/ inter n=20	Standard error	95% Confidence interval	
				Lower	Upper
CROM	Extension	0.91	0.03	0.86	0.97
	Flexion	0.85	0.08	0.76	0.94
	Right lateral flexion	0.93	0.03	0.89	0.98
	Left lateral flexion	0.89	0.04	0.81	0.96
	Right rotation	0.76	0.07	0.63	0.90
	Left rotation	0.81	0.05	0.70	0.92
Fleximeter	Extension	0.88	0.05	0.80	0.95
	Flexion	0.84	0.06	0.74	0.93
	Right lateral flexion	0.85	0.06	0.75	0.94
	Left lateral flexion	0.81	0.07	0.70	0.92
	Right rotation	0.66	0.09	0.49	0.83
	Left rotation	0.75	0.08	0.61	0.89

CROM=cervical range of motion.

considered excellent for the movements of extension, flexion, right lateral inclination, left lateral inclination, and moderate for the movements of right and left rotation (Table 3).

## Discussion : : : .

The CROM is a validated tool, accurate and easy to use; however, has the disadvantage of being expensive and only can be used in measuring cervical ROM. However, the Fleximeter, was more financially accessible, was capable of measuring the ROM of several joints, but there was a need for it to be repositioned for each measurement, which could become a factor for alterations of the measurements.

In the comparison between the two tools, it was observed that there was excellent agreement for the majority of the cervical movements. These results indicated that the measurements obtained in the cervical assessments with CROM were equivalent to those obtained with the Fleximeter, thus confirming the possibility of using the Fleximeter as a substitute for the CROM in clinical practice.

The results of this study demonstrated that the measurements performed by the CROM had excellent intra-examiner reliability for most cervical movements, with moderate values only for flexion and right rotations. In turn, in the inter-examiner reliability for this same tool, there were excellent values for all assessed cervical movements. These results agreed with data described by Cappuano-Pucci et al.<sup>33</sup>, who observed an intra-examiner reliabilities ranging from 0.63 to 0.90, classified from moderate to excellent, and an inter-examiner reliability ranging from 0.80 to 0.87, classified as excellent. The CROM was, therefore, a reliable instrument for measuring cervical ROM.

In the evaluation carried out with the Fleximeter, the intra-examiner reliability was considered moderate for most cervical movements, except for the values of right lateral inclination, and right rotation, which were considered to be excellent. The inter-examiner reliability was considered moderate only for the movements for right and left rotations, but, for the other movements was classified

as excellent. These results do not agree with the values found by Lima et al.<sup>34</sup>, who reported excellent reliability for rotation and moderate for inclination. One probability for the conflict in these results might be the type of sample because, although both studied populations were asymptomatic, in the study by Lima et al.<sup>34</sup> the subjects who were evaluated were of different age groups within the same group, a variable which could influence the ROM. Therefore, considering the ICC values for intra- and inter-examiner reliability, the Fleximeter is a device whose use can also be recommended for the evaluation of cervical ranges.

Finally, it can be affirmed that, since the reliability levels found for both tools were classified, either as, as moderate or excellent (0.66-0.88), their use is recommended for evaluation of the cervical ROM. The reliability study of the devices, such as these, are useful not only for better standardization in research, but to guide physical therapists as to the validity of using these instruments in their clinical practices. The Fleximeter, is more affordable and accessible, yet can be used for the evaluation of other body segments, different from CROM, which has excellent reliability, but can not be used for other purposes.

A limitation of this study is that the assessment of asymptomatic individuals does not guarantee that the reliability of the tools was reproduced when evaluating individuals with a disability in the cervical segment. Therefore, further studies are needed on the Fleximeter's reliability, since there is little information available on the evaluation of symptomatic populations.

## Conclusions : : : .

The results showed that the values obtained in the evaluation of the cervical ROM made with the Fleximeter agreed with the values obtained with the CROM. In addition, both tools had intra- and inter-examiner reliabilities which ranged from moderate to excellent, which proved its potential for use in clinical practice.

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