0008-3194/98/222–228/$2.00/©JCCA 1998

Interexaminer and intraexaminer reliability of cervical passive range of motion using the CROM and Cybex 320 EDI

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Objective: *To compare the interexaminer and the intraexaminer reliability of measuring passive flexion and extension ranges of motion of the cervical spine, using a Cybex 320 EDI (inclinometer) and a Cervical Range of Motion (CROM) instrument.*

Design: *Blind, repeated measures of passive cervical flexion, extension range of motion by three different examiners.*

Setting: *Private multi-disciplinary clinic.*

Participants: *27 volunteers, varying from asymptomatic to symptomatic conditions of the cervical spine, 14 males and 13 females, aged 10–67 years.*

Intervention: *Measurement of passive cervical flexion, extension range of motion using the Cybex 320 EDI (single inclinometer) and the CROM by three blinded examiners, following the protocol in the respective manufacturers' manuals. The three examiners assessed each of the 27 subjects twice on each instrument for flexion and extension.*

Results: *The intraexaminer reliability for both the CROM and the Cybex 320 EDI were high, 95% confidence interval ICC values of .96–.99 and .85–.96 were found for the CROM and the Cybex 320 EDI instruments, respectively. The average (standard deviation) range of motion between the CROM and the Cybex 320 EDI for flexion was found to be 49.5 (15.3) and 53.9 (17.5) and extension 62.9 (22.6) and 43.6 (16.7), respectively. The interexaminer reliability analyses also showed high correlations (ICC 95% CI = .96 – .97, ICC 95% CI = .80 – .89) for the CROM*

Objectif *: Comparer la fiabilité des mesures, entre examinateurs et d'un même examinateur, de l'amplitude des mouvements passifs de flexion et d'extension de la colonne cervicale à l'aide d'un inclinomètre Cybex 320 EDI et d'un instrument de mesure de l'amplitude des mouvements cervicaux (CROM).*

Méthode *: Mesure de façon anonyme et répétée de l'amplitude des mouvements passifs de flexion et d'extension de la colonne cervicale par trois examinateurs.*

Lieu *: Clinique privée multidisciplinaire.*

Participants *: 27 volontaires, 14 hommes et 13 femmes, âgés de 10 à 67 ans, présentant des affections symptomatiques et asymptomatiques de la colonne cervicale.*

Intervention *: Mesure de l'amplitude des mouvements passifs de flexion et d'extension de la colonne cervicale à l'aide de l'inclinomètre simple Cybex 320 EDI et du CROM par trois examinateurs anonymes, selon le protocole décrit dans les manuels des fabricants respectifs. Les trois examinateurs ont évalué les 27 sujets à deux reprises à l'aide des deux instruments de mesure de flexion et d'extension.*

Résultats *: Pour ce qui est d'un même examinateur, la fiabilité tant pour le Cybex 320 EDI que pour le CROM était très élevée, l'intervalle de confiance étant à 95 % et les limites, à 0,96–0,99 et à 0,85–0,96 pour le CROM et le Cybex 320 EDI respectivement. L'amplitude moyenne (écart type) des mouvements entre le CROM et le Cybex 320 EDI était de 49,5 (15,3) et de 53,9 (17,5)*

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and Cybex 320 EDI, respectively.

Conclusion: *Range of motion determination is an integral component of an individual's assessment when the cervical spine is in question. Choosing the most appropriate instrument and matching the choice to the parameters of the individual venue, considering, i.e. cost-effectiveness for assessment, and quality makes our result findings informative and pertinent. While both instruments yielded clinically acceptable intraexaminer and interexaminer agreement, relevant to practitioners treating injured persons, the CROM was found to have a higher reliability for cervical passive range of motion when evaluating passive flexion and extension.*
(JCCA 1998; 42(4):222–228)

KEY WORDS: chiropractic, cervical, range, CROM, Cybex.

pour la flexion et de 62,9 (22,6) et de 43,6 (16,7) pour l'extension, respectivement. Pour ce qui est des analyses de fiabilité des mesures des examinateurs, on note également une forte corrélation entre les mesures (intervalle de confiance à 95 % et limites à 0,96 − 0,97 pour le CROM; intervalle de confiance à 95 % et limites à 0,80 - 0,89 pour le Cybex 320 EDI respectivement).

Conclusion *: La mesure de l'amplitude des mouvements fait partie intégrante de l'évaluation des patients qui présentent des troubles de la colonne cervicale. Le choix d'un instrument approprié et de son adéquation aux paramètres de chaque cas ainsi que l'étude de la qualité et du rapport coût-efficacité de l'évaluation confèrent aux résultats obtenus un caractère informatif et pertinent. Même si les deux instruments ont permis de rapprocher les données obtenues par différents examinateurs et un même examinateur – ce qui est important pour les praticiens qui traitent des patients ayant subi des blessures – le CROM s'est révélé plus fiable que le Cybex en ce qui concerne la mesure de l'amplitude des mouvements passifs de flexion et d'extension de la colonne cervicale.*
(JACC 1998; 42(4):222–228)

MOTS CLÉS : chiropratique, colonne cervicale, amplitude des mouvements, CROM, Cybex.

Introduction

The reliability of clinical diagnostic and treatment outcome measurements is generally recognized as being important in clinical research and is gaining recognition as being important in clinical practice. One of the most common outcome measurements in clinical practice is joint 'range of motion' (ROM), and some of the available instruments used to measure range of motion include: visual estimation, universal goniometer, gravity goniometer, tape measure assessment, electro-goniometer (Metrocom), Myrin gravity reference goniometer, Leighton flexiometer, hydro goniometer, bubble goniometers, protractors, radiographs, inclinometers and the CROM. With so much to choose from, a clinician must select a device which is safe, easy to use, economical, clinically useful, reliable and valid. Reliability is defined as, "the consistency or repeatability of measurements when in fact there is no chance; the degree to which repeated measurements are error-free and the degree to which they agree." Intraexaminer reliability for most kinds of measurements is generally higher than interexaminer reliability. The level of reliability is also dependent upon the instrument, the body region being measured and the time interval between repeat measurements.

According to Cole,[19] the cervical spine is likely the most difficult body region to evaluate for motion, due to the lack of bony landmarks and the depth of soft tissue overlying this region. Yet cervical spine range of motion is one of the most frequently used forms of ROM assessed in clinical practice, and some form of goniometer is often the instrument of choice. Pandya et al.,[20] found 2-arm goniometer intraexaminer reliability high for all cervical measurements (ICC ranged from .81 to .94); however, interexaminer reliability was extremely variable (ICC ranged from .25 to .91). Yet, for the universal and gravity goniometer. Tucci[21] found interexaminer reliability highly clini-

cally significant (ranging from .81 to .91) while intraexaminer showed greater variation (ranging from .38 to .91). The study by Rheault et al.,[16] found the reliability for the CROM unit between examiners to range between ICC = .76 to .98, indicating moderate to high reliability. Several other studies have shown high intraexaminer reliability of the CROM unit, but none have determined the reliability of a more recently designed device, the Cybex 320 EDI. Our study compared the clinical flexion-extension intraexaminer and interexaminer reliability of the CROM and the Cybex devices. Clinically significant agreement was judged to by ICC > .8.

Methods and materials

Subjects

The instruments were tested on 27 patients (13 females, 14 males) randomly selected from a private multi-disciplinary clinic. The patients' ages ranged from 10–67 (mean 38.6 years) years. The criteria for admission into this study were: both symptomatic and asymptomatic subjects, with no nervous tic or tremor. An informed written consent was obtained from all subjects.

Examiners

The CROM and Cybex 320 EDI measurements were taken by three chiropractic students from the Canadian Memorial Chiropractic College. All examiners completed a 3 hour training session prior to testing subjects, to correctly learn the protocols per the manufacturers' instructions in their respective manuals.

Instrumentation

We used CROM and Cybex devices to measure flexion and extension passive ROM in the cervical spine. Both instruments were calibrated according to the manufacturers' specifications.

Figure 1 Cervical spine flexion measurement using the CROM.

Figure 2 Cervical spine flexion measurement using Cybex 320 EDI.

Procedure

The subjects were seated on a straight high back chair with shoulder straps to eliminate thoracic motion when testing with the CROM instrument. The subjects' arms were placed on the arm rests in a relaxed position. The subjects' feet were positioned flat on the floor (Figure 1). In contrast, the Cybex 320 EDI required the subjects to be standing with their arms at their sides in a neutral position (Figure 2). The placement of the devices on the subjects were done according to the manufacturers' recommendations.

Each of the three examiners measured one set of three extension and flexion movements of the cervical spine with both instruments. Prior to the measurements, each subject performed three repetitions of flexion and extension in order to increase compliance of the soft tissue of the neck.

Each examiner instructed each subject to relax his/her head to allow the examiner to move the subject's head through a passive range of motion, until the movement was stopped by either muscle tightness, pain, or until a substitution movement occurred (i.e. other than cervical flexion and extension movement including the thoracic region). All measurements were recorded independently by a non-examiner to blind the examiners from their measurements. The subjects were given a two minute time interval between each measurement taken by the examiners for both flexion and extension and both instruments.

Data analysis

The CROM and Cybex cervical flexion and extension data were analysed for intraexaminer and interexaminer reliability using the fixed effects Intraclass Correlation Coefficient (ICC). An ICC > .8 was judged clinically acceptable. The Intraclass Correlation Coefficient (ICC) were calculated with a 95% Confidence Interval (95% CI).

Intraexaminer reliability was calculated by comparing the first and second measurements made by each examiner with the same devices. The Pearson Product-Moment Correlation Coefficient was not calculated. It is inappropriate for measuring strength of agreement between two methods of measurement because it is a measure of the linear association between two variables and it ignores systematic bias. Two measures can be strongly associated linearly but have poor agreement.

Intraclass Correlation Coefficients (ICC) were calculated to quantify the degree of interexaminer reliability of the measurement. We calculated ICCs for between-examiner reliability by comparing the measurements made by each pair of the examiners using the average of the examiners' repeat measurements.

Results

The ICCs for interexaminer reliability of the CROM for flexion and extension measurements were found to be .96 and .97, respectively. The ICCs for interexaminer reliability for CYBEX for flexion and extension measurements were found to be .89 and .80, respectively.

Intraexaminer reliability ICCs for flexion and extension measurements of CROM for examiners ranged from .96 to .98 and .96 to .99, respectively. For CYBEX, these ranged from .91 to .92 for flexion, and extension ranged from .85 to .96 (Table 1).

Discussion

The results of our study show that both the CROM and Cybex 320 EDI instruments yielded acceptable and very high interexaminer and intraexaminer reliability coefficient (ICC > 0.8). The CROM however, appeared to have all around superior reliability and was clinically superior to the Cybex, for reasons discussed below.

We found the CROM to be simple and easy to use. The design gave the examiners freedom of use of their hands; it is also light-weight and portable. Our study supports previous studies which have shown the CROM to be very reliable both between and within examiners. The Cybex 320 EDI instrument is also portable and diverse with its applications, although our study only addressed cervical ranges of motion (flexion and extension). The Cybex 320 EDI takes into account both upper and lower cervical ranges of motion and calculates gross ranges of motion.

We found some negative aspects with both instruments which are worthy of note. For example, the CROM can only be used to measure ranges of motion in the cervical spine, and while doing this, it cannot distinguish upper or lower components of the gross range in the cervical spine. This unit is also quite expensive in light of its limited application. Regarding Cybex 320 EDI, we felt that the hand unit was too sensitive to motion of the examiner's hand, which often resulted in error or unnecessary remeasuring of the patient. Measuring cervical extension was difficult and prone to error, as we found the hand unit

Table 1
Summary of the intraexaminer and interexaminer reliability of the CROM and Cybex 320 EDI

			CROM ICC 95% CI	Cybex ICC 95% CI
INTEREXAMINER RELIABILITY	Flexion		**0.96 + 0.08**	**0.89 + 0.13**
	Extension		**0.97 + 0.07**	**0.80 + 0.18**
INTRAEXAMINER RELIABILITY	Flexion	Examiner 1	0.96	0.92
		Examiner 2	0.98	0.92
		Examiner 3	0.98	0.91
		Average	**0.97 + 0.07**	**0.92 + 0.11**
	Flexion	Examiner 1	0.96	0.85
		Examiner 2	0.99	0.93
		Examiner 3	0.98	0.96
		Average	**0.98 + 0.06**	**0.91 + 0.12**

Table 1a
Intraexaminer interinstrument paired samples T-test for cervical flexion

Examiner	Trial	MD (Mean Difference)	SDD (SD Difference)	T-test	Probability
1	1	−3.185	9.560	−1.731	0.095
1	2	−3.519	8.031	−2.277	0.031
2	1	−5.852	8.374	−3.631	0.001
2	2	−3.926	10.084	−2.023	0.053
3	1	−4.630	8.049	−2.989	0.006
3	2	−5.926	8.539	−3.606	0.001

Table 1b
Intraexaminer interinstrument paired samples T-test for cervical extension

Examiner	Trial	MD	SDD	T-test	Probability
1	1	18.519	19.049	5.051	0.000
1	2	20.889	14.703	7.382	0.000
2	1	20.185	12.646	8.294	0.000
2	2	19.667	12.058	8.475	0.000
3	1	19.148	12.031	8.270	0.000
3	2	19.22	11.369	8.785	0.000

Table 2a
Intraexaminer intrainstrument (CROM) paired samples T-test for cervical flexion (FL) and extension (EX)

Examiner	ROM	MD	SDD	T-test	Probability
1	FL	−2.815	4.820	−3.034	0.005
1	EX	−0.481	6.975	−0.359	0.723
2	FL	−1.444	3.154	−2.380	0.025
2	EX	−0.074	4.085	−0.094	0.926
3	FL	0.111	3.286	0.176	0.862
3	EX	0.0481	4.282	0.584	0.564

Table 2b
Intraexaminer intrainstrument (Cybex) paired samples T-test for cervical flexion (FL) and extension (EX)

Examiner	ROM	MD	SDD	T-test	Probability
1	FL	−3.184	7.199	−2.272	0.032
1	EX	1.889	9.943	0.987	0.333
2	FL	0.481	7.480	0.334	0.741
2	EX	−0.593	7.137	−0.431	0.670
3	FL	−1.185	6.951	−0.886	0.384
3	EX	0.556	4.406	0.655	0.518

Table 3
Interexaminer intrainstrument Standard error (SE) for cervical FL and EX

Instrument	ROM	SD	SE (Degrees)
CROM	FL	11.34	2.18
CROM	EX	7.24	1.39
CYBEX	FL	16.66	3.21
CYBEX	EX	4.07	0.78

Table 4
Interexaminer interinstrument Standard error (SE) for cervical FL and EX

Trial	ROM	SD	SE (Degrees)
1	FL	18.18	3.50
2	FL	14.38	2.77
1	EX	55.13	10.61
2	EX	57.14	11.00

to be too large to allow for placement of the instrument of the suggested landmark, while the subjects were in full extension. Cybex 320 EDI does not permit full freedom of the examiner's hands since the hand unit must be held in place throughout measurement. Additionally, the subjects were required to hold the position while the data was entered into the unit, which may cause some symptomatic patients to endure unnecessary discomfort. Another potential for error with the Cybex 320 EDI instrument may be due to its protocol for positioning, whereby the standing subject may incur postural swaying.

As this study was only utilizing subjects from one clinical setting, this study may not be a true representation of the population; however, we have no reason to believe that our subjects were grossly atypical of a normal population. It should also be noted that the Cybex 320 EDI instrument has many other applications, other than cervical range of motion measurements, and other research may substantiate its broader range of application.

Conclusion

Overall both instruments showed reliable findings. Our recommendation for patient positioning during measurement taking could enhance reliability. It would be of value to study the remaining cervical ranges of motion of right and left lateral bending and rotation using these two instruments. Assessing concurrent criteria validity by using x-rays as a gold standard is also a consideration for future studies.

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