Validity and Reliability of Dual Digital Inclinometer in Measuring Thoracic Kyphosis in Women over 45 Years

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Abstract

Objective:Accurate measurement of the Thoracic Kyphosis Angle (TKA) has great value for both evaluating patients and monitoring treatment progress. Dual Digital Inclinometer (DDI) has introduced as a non-invasive device that can measure the kyphosis angle. Because of lack of sufficient data, this study was aimed to determine the validity and the reliability of the DDI in measuring TKA in a group of women.

Materials and Methods:In this study, TKA was measured by DDI three times in 20 women aged 45-70 years. The first two measurements were taken with an hour apart in the same day, to assess the within -day and the third measurement was taken a day later to assess the between-day reliability. Finally, the validity of obtaining values of the TK with DDI compared with Cobb's angle as a gold standard.

Results:The ICC between the measurements from the Cobb's angle and DDI method was 0.86. TKA measurements using DDI were shown to be reliable with high Inttraclass Correlation Coefficient (ICC) values, 0.92 and 0.87 for within- day and between- day respectively.

Conclusion:According to the present study, the DDI is a valid and reliable device for non-invasive and clinical measurement of TKA in women over 45 years.

Keywords: Thoracic kyphosis angle; Dual digital inclinometer; Validity; Reliability; Women

Introduction

The normal thoracic spine has a kyphotic curvature ranging from 20-50 degrees [1]. The angle increases throughout life, especially in women [2,3]. Factors associated with progression of the kyphosis are: anatomical and structural changes in the intevertebral disc, decreased mass of the anterior vertebral bodies and imbalance between muscles and soft tissues supporting the vertebral column [4,5].

Postural kyphosis is the most common type of postural disorders, associated with interscapular pain syndromes, respiratory dysfunction, reduced physical activity, and more complicated conditions including Scheuermann's disease and Ankylosing Spondylitis [6-8]. Patients with psychosocial problems such as Major Depressive Disorder (MDD), General Anxiety Disorder (GAD) and lack of self-confidence also showed a marked kyphosis [9]. Moreover, there are significant negative consequences of increased kyphotic angle on Activity of Daily Living (ADL) and general health status in women [3] .

The gold standard for the measurement of Thoracic Kyphosis Angle (TKA)is calculation of Cobb's angle from radiological images [10]. Nevertheless, this method is expensive and needs a certain amount of X-ray radiation. As a result of the dangers of exposure to radiation, it is impossible to use this method for screening patients in follow-up studies [11]. Therefore, alternative methods such as Brauner Kyphometer, Flexicurve, Goniometer, Spinal mouse and Inclinometer have been recommended [10,12]. However, these methods have their own limitations. For instance, flexicurve, a suitable instrument for studies with large sample size, takes a considerable time and allows more measurement errors [13,14]. Using Spinal Mouse requires a complex set up which makes it difficult to be applied in the research or clinical environment [15].

Inclinometers, have been used to measure the Range of Motion (ROM) and the curvatures of the spine [16]. A type of inclinometer, so called Dual Digital Inclinometer (DDI), with the ability to increase rates of data registration by recording six different input of data continuously has an advantage over other Inclinometers [17,18].

Previous studies showed acceptable reliability and validity of the DDI in evaluating lumbar lordosis and range of cervical spine flexion and extension movements [19,20]. Although, there is only one published study related to the reliability and validity of the DDI, which has done on a group of Hyper-Kyphotic patients from both genders [14]. Despite the importance of evaluating the TKA in women [3,7], in our knowledge, no study has been published in this regard. Therefore, the present study assessed the validity of the DDI in a group of non-

osteoporotic women over 45-years. In addition, both its within day and between days reliability were studied.

Materials and Methods

Participants

Twenty females aged 45-70 years were enrolled into this cross-sectional study. These participants were selected from a larger sample of women with back pain referred by a general practitioner. Their lateral view x-ray image was obtained from a same radiology centre upon a consultant rheumatologist's request.

The exclusion criteria were: 1) structural spinal problems 2) inflammatory or osteometabolic diseases 3) any congenital disorders and 4) history of vertebral fractures and surgical spinal fixation or lower limb surgery.

The Ethics Committee of Shahid Beheshti University of Medical Sciences approved the study and all participants completed a written informed consent form before evaluations.

Instrument

Acumar TM digital inclinometer, Lafayette Instrument Company from USA (model ACU002) was used for all inclinometric measurements (Figure 1). This device consists of two sections, linked by a line. The main (reference part) has an LCD screen, to show the calculated data. For exact measurement, the two sections should align with each other, parallel to the horizontal plane, so the number "zero" appeared on the screen.

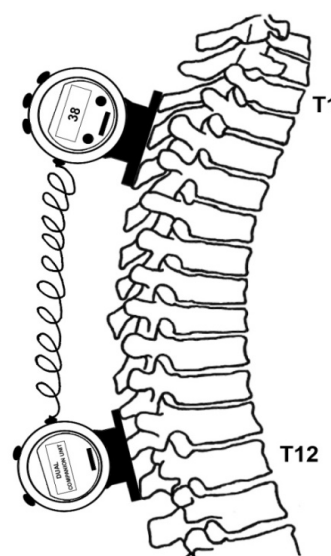**Figure 1:** Dual Digital Inclinometer

Procedure

After recording demographic information, the spinous process of the first and the last thoracic vertebra (T1 and T12) identified and marked as described below:

To find T1 vertebrae, participants were asked to bend forward their heads (Head/Neck Flexion) and the spinous process of the seventh cervical vertebra was identified [1]. The bony prominence below the C7 was marked as the spinous process of the T1. The spinous process of the T12 can also be verified by identification of the fifth lumbar vertebrae and palpating superiorly from that point [21]. After marking these two landmarks, the examiner asked participants to perform the following instructions in order to reach their natural position prior to DDI evaluations [21].

1) Swaying arms (Upper limbs Flexion/Extension)

2) Bending head (Head Flexion/Extension)

3) Deep breath

Every step performed three times and at the end, participants were asked to stand steady. Then, the reference and the measuring parts of DDI were placed on the spinous processes of T1 and T12 respectively. The value seen on the screen was the amount of the TKA (Figure 2) [14].

Figure 2: Measuring TKA using dual digital inclinometer: Schematic view

The same examiner obtained three measurements. The first and the second measurements were performed on the first day, with an hour interval (for evaluation of within-day reliability) and the third one on the next day (for evaluation of between-day reliability) at the same time of the day. After gathering data on DDI, the Cobb's angle was calculated on the lateral x-ray image as described below:

Two lines are drawn along the superior surface of the body of the T1 and the inferior surface of the body of the T12. Then, two straight lines drawn perpendicular to previous ones and the angle at their cross-point was measured with a protractor [22]. All the measurements have done with the same instrument and the same marker.

Statistical analysis

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version17.The validity of the measurement was assessed using the comparison between the results of the first measurement and the calculated Cobb's angle. Intraclass Correlation Coefficients (ICC) between the first and the second, and also the first and the third measurements were used to assess within day and between day reliability, respectively. By definition, ICC amount between 0.25 to 0.50 suggests a poor degree of relationship, 0.50 to 0.75 suggests a moderate to good degree of relationship, and above 0.75 suggests a good to excellent degree of relationship [23]. In addition, Standard Error Measurement =SEM with a 95% confidence interval (CI=95%) was calculated. We also conducted Bland-Altman

analysis to assess agreement between the two measurement methods [24].

Results

Table 1 displays demographic characteristics of the participants.

Variable	Mean	Standard Deviation	Minimum	Maximum	Range
Age (years)	57.20	7.67	45	70	25
Height (cm)	156.20	8.32	140	170	30
Weight (kg)	67.76	10.60	42.80	93.80	51
BMI (kg/m2)	27.75	4.47	20	38	18
The Cobb angle (degrees)	46.80	10.93	30	64	34
Angular measurement of the kyphosis by the DDI (degrees)	45.01	8.69	30	60	30

Table 1: Mean (± SD) of demographic information and the thoracic kyphosis angle measurements of participants (n=20)

The ICC and the SEM for TKA measurements are presented in Table 2. The ICC between the DDI and Cobb's angle methods were 0.86, p<0.0001 and the SEM was 3.23˚. The Bland-Altman diagram (Figure 3) shows the agreement between the two measurement methods. The means of the variables were shown on the horizontal axis and the differences on the vertical axis. The average difference ± 2 standard deviation was defined as the consistency range of the two measurements. The average difference was -1.55 with a CI between -15.21 -12.26, which implies the congruence of the measurements with each other.
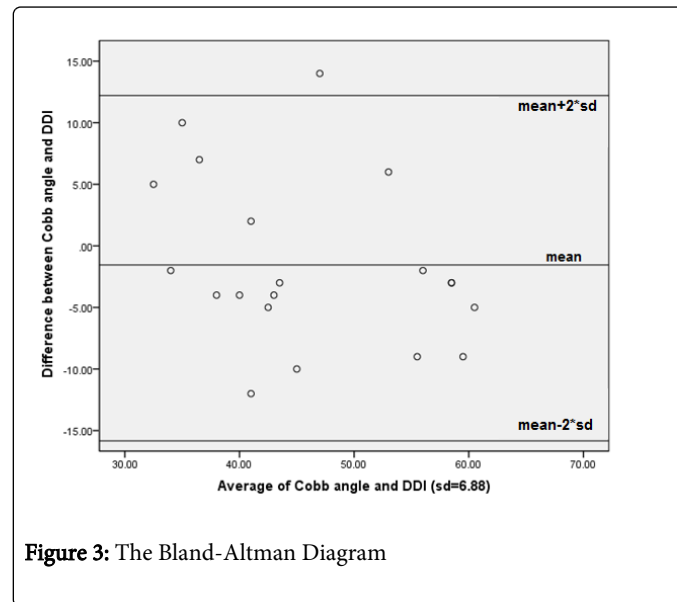

Figure 3: The Bland-Altman Diagram

Variable	ICC*		SEM**	
Thoracic kyphosis angle	Within-day	Between-day	Within-day	Between-day
	0.92 Sig***<0.001	0.87 Sig<0.0001	1.98˚	2.41°

Table 2: Values of ICC and SEM for the within-day and between-day reliability of the DDI in measuring the kyphosis angle

*ICC: Intra-class Correlation Coefficient, **SEM: Standard Error Measurement, ***Sig: Significant

Discussion

Nowadays, studying reliability and validity of instruments, plays an important role in providing a strong foundation for researches' results and/or findings from clinical assessments. Validity, demonstrates how and to what extent the findings support the interpretations of test results for a particular purpose. Reliability, as a component of validity, refers to the reproducibility or consistency of values from one assessment to another [25].

The main purpose of the present study was to evaluate the validity and reliability of the DDI as a non-invasive method to assess the TKA in women. Comparison of measurements using the DDI with those from radiographs indicated that the DDI has acceptable validity in measuring TKA. The previous study that evaluated the validity of two non-invasive methods (the Flexicurve and the DDI) in participants with hyperkyphosis was performed by Azadinia et al. [14]. In agreement with our results, they reported high validity of DDI (ICC=0. 81) in 21 subjects aged between 50 to 80 years. However, it

should be noted that this study concerned both genders whereas ours focused on females and this may be one of the reasons for the relatively higher validity obtained in our study. Although Azadinia et al. [14] did not report any diagnostic criteria to include participants with hyperkyphosis, the finding that at a similar age the normal kyphosis angle differs between men and women is important[2].

The results showed high levels of reliability of Within-Day measurements, which indicates the accuracy of the DDI method. This finding is similar to Azadinia et al. [14] (ICC=0.97). The possible explanation for the small difference between the ICCs may be the longest interval (rest) between measurements in our study. Since Azadinia et al. [14] have chosen five-minute interval between measurements, after preparing for the first assessment, body condition has less time to deviate from its primary position.

To the authors' best knowledge, the present study was the first one to investigate between day reliability of TKA measurement using the DDI. High reliability of the DDI in the measurement of the lumbar lordosis has been reported before by Ng et al. [26] and Garmabi et al. [20] (ICC= 0.96 and ICC=0.95, respectively). In addition, TKA measurement by non-digital inclinometer was shown high accuracy.

The advantage of the digital inclinometer is in its automated calculation, which leads to lower measurement error and more efficiency [27,28].

This study had some limitations. As the radiological images were needed, we only recruited a limited number of non-osteoporotic females. Therefore, we urge caution in generalizing these results. In addition, potential inaccuracies on palpation of anatomical landmarks can be source of error during the measurement procedure. As a single examiner performed the measurements, further studies are warranted to assess inter-rater reliability.

Conclusion

According to the present study, DDI has acquired a high reliability and validity in the TKA evaluation. Therefore, the DDI can be used for clinical assessment of spinal thoracic curvature, as a simple and non-invasive method.

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