World Applied Sciences Journal 28 (12): 2188-2192, 2013
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2013.28.12.770

Determination Reliability and Validity of Ultrasonic Wave Arc Detector Device in Measurement of Lumbar Lordosis Angle

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Abstract: *Objective*: The aim of thepresent study is to determine Reliability and Validity of Ultrasonic Wave Arc Detector Device in Measurement of Lumbar Lordosis Angle Compared with the golden standard X-ray method. *Methodology*: After making the device, Lumbar lordosis angle of31participants were measured by three examiners three times in at least two hours intervals with the device for determining of its reliability and Lumbar lordosis angle of15 participants were measured through radiographic and proposed techniques In order to measure the device validity. The participants were selected from available individuals and volunteers' people of Birjand city. *Findings*: reliability ofthe first, secondand third examiners are 0.97, 0.98 and 0.98 respectively and reliabilitybetweenexaminersperiods are 0.96, 0.97 and 0.95 respectively, the Correlation betweentheproposed method andthe reference method is (r=0.95) and it was found to be significant ($p \leq 0.05$). *Discussion and Conclusion*: the high Reliability and validityoftheproposed methodcan be due tothe least interference of examinerinmeasurement process and use of high-precisionengineering andcomputationalmethods. So this method can be used for measurement of lumbar lordosis angle Along with other non-invasive methods can be used as astableand reliablemethod.

Key words: Validity · Reliability · Ultrasound · X-ray and lumbar lordosis

INTRODUCTION

In many sports medical research, accurate determination of the thoracic and lumbar lordosis angles has been as one of the sources of error affecting the results of the study [1, 2] so researchers are looking for the best and most appropriate way to measure the respective angles [3]. Detection of spine abnormality and measuring waist and back arches angles is possible by use of a variety of invasive and noninvasive methods [4]. Uses of methods such as radiography, CTS, fluoroscopic, MRI are invasive procedures that are used for this work. Non-invasive method that are used, divided into two categories, contact and non-contact methods [5].

One of the most famous and oldest invasive methods that most experts use it and has been known as the gold standard in measuring lordosis angle, is Using X-ray method [6]. The dangers of exposure to x-rays, need of long time for measuring, Unavailability, high cost, movement of participants during treatment and above all high probability of error because of positions and techniques used for photography are disadvantages of the method [7]. Due to harmful nature of invasive methods that can be followed by risks such as bone cancer in men and breast cancer and abortion in women [4], today, however, noninvasive methods compared to invasive methods have various defects, but Non-invasive measurement methods have attracted more attention [8].

On the one hand, spending long time for measuring and high expenses and more important than all of these high measurement error are the most important Disadvantages of non-invasive measurement techniques [9]. Consequently, further research has been done to reduce and eliminate these defects and various non-invasive methods have been proposed.

Items and defects listed in non-invasive and invasive methods caused the question that if a machine can be made that with new method (non-invasive) calculate

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lumbar lordosis angle with negligible error, high accuracy, in less time and with less cost and it can be used along with other conventional methods of measuring?.

MATERIALS AND METHODS

After making machine and determine its physical accuracy (Figure 1), to determine its validity and reliability, the following treatments have been done: two groups of volunteer and available people of Birjand have been chosen. A group of 31 persons and other one 15one. Lumbar lordosis angle of 31 participants were measured in two hours intervals by three examiners at three times to determine to determine the reliability of the device. Lumbar lordosis angle of 15 participants were measured by radiographic method to determine the validity of the device and the values were recorded.

Method of Using X-ray images: in the method of using radiography images for measuring lumbar lordosis angle, first an individual in normal position with bare feet stand on a cardboard that had been prepared separately for each individual, feet were shoulder width apart and they were asked to distribute body weight evenly on both feet and to look forward. The device (Fig. 2) put between legs of participants for the standardization of test conditions and preventing displacement of the spine. After Two minutes that the person acquires its normal condition, images were taken by the device, file containing the images submitted to researcher. This method was performed only one time and it was because of not accepting any examiner interference and avoiding excessive exposure to harmful radiography rays.

Method of Using Made Device: The proposed method for determining the angle of lumbar lordosis consists of five steps. At first step in Hopenfield method, spinal nerve (S2&T12) was identified [10]. In the second step researcher has considered issues related to standardization of condition for each participants. The participants were asked to stand backward to the device and grasp the spine stabilizer with both hands. In the third step laser of distance-meter device that shows the target point, will be set on first point (an appendage of the twelfth thoracic vertebra thorn) that was marked with a marker. It may be done by a stopper button embedded at the device. In the forth step press the start button embedded on the micro-controller. The device automatically moves from top to bottom of back arc and record desired data and keeps it in the memory. To stop the device, we use stop button when the laser light set on the thorn of second sacral vertebra that was marked with a marker. After stopping the device, the coordinates of the points were transferred to the proposed method in the computer. In the fifth step if identified points be named top- down 1, 2, 3,…, n respectively, the first component of the vector feature angle or curve is considered at point 1 and is easily calculated. If we show the position of point I with (x_i, y_i) the amount of component it is calculated from component of the feature f (i) according to the following relationships for $i = 1,2,...,n$ respectively. And at this step coordinates of points transfer to application of the proposed method and calculate the angle that it can be done in less than 1 second. Average time needed to measure lumber lordasis angle with the proposed method is about 3 minutes.

To determine thereliability of thedevice, after abrief descriptionabout how touse the devicefor threeexaminers, they were asked to measure and record lumbar lordasis of 20 participants at three times and with at least two hours intervals. Information relating to each examiner was analyzed to determine the reliability and objectivity of the device. SPSS 16 and EXEL 2007 were used to analyze the data, draw graphs and to test hypotheses. To determine the relationship between data resulted from each method (validity determination), first, the scatter plot was used and then, according to the data distribution, the Pearson correlation coefficientwas used. Cronbach's alpha test was used to determine the reliabilityandobjectivityofthe device.

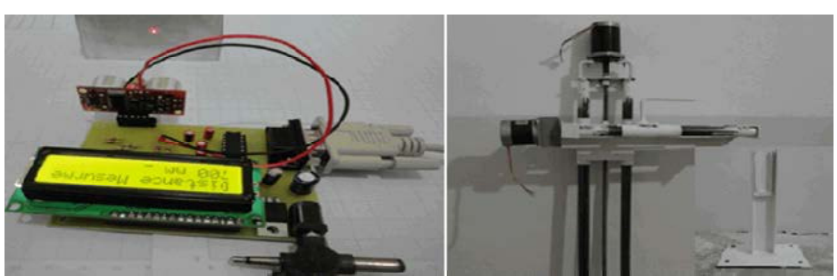

Fig. 1: Hardware mover and the final sample distance meter ultrasonic device

Fig. 2: Spinestabilizer

$$l_1 = \sqrt{(x_i - x_{i+1})^2 + (y_i - y_{i+1})^2}$$

$$l_2 = \sqrt{(x_{i+1} - x_{i+2})^2 + (y_{i+1} + y_{i+2})^2}$$

$$l_3 = \sqrt{(x_i - x_{i+2})^2 + (y_i - y_{i+2})^2}$$

$$f(i) = \cos^{-1}\left(\frac{l_1^2 + l_2^2 - l_3^2}{2 l_1 l_2}\right)$$

RESULTS

Table 1 describes information relating to the group of 31 persons that reliability test had been done on then with proposed method by three examiners and also shows the information relating to group of 15 people that proposed tests and X-ray test had been done on them to determine the validity.

In Table 2, the objectivity coefficients of three examiners in measuring of lumber lordosis angle have been calculated by the device. Each examiner had three measuring. First column shows the objectivity of the first measuring. The second and third column shows the objectivity for two other one. In the forth column the median of examiners measurementshave been used for calculations. Comparison of the scores shows that the accuracy of the device is so high that even use of median relating to first three times cause no noticeable difference in reliability of the device.

In Table 3, shows the reliability of three times measurements of lumber lordasis angle using arc detector for three examiners have been showed. As can be seen, the reliability coefficient of three examiners for the device is the same and is high level.

Table 4 shows that the observed differences for the overall performance of each examiner are not significant. ($p=0.113$ & $f_{(2,38)}=2.39$) also, observed differences in each

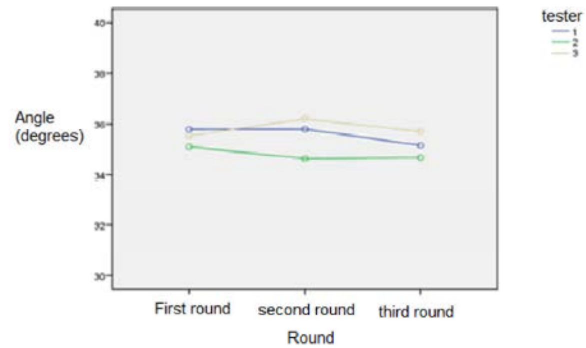

Fig. 3: Liner chart of lumber lordasis angle changes three times of three examiners with the device

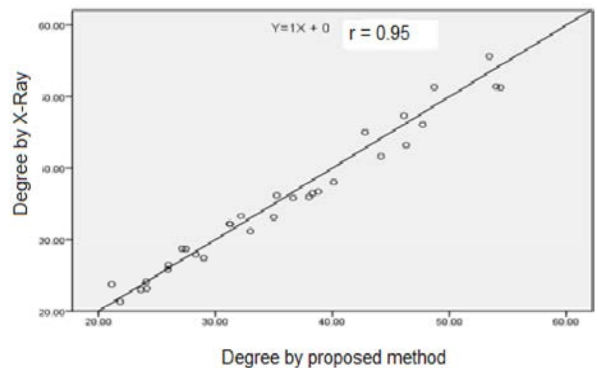

Fig. 4: Scatter plot of lumber lordosis of 31 participants according to measurement by X-ray method

time test are not significant ($f_{(2,38)}=1.14$ & $p=0.331$). Also interaction of test time and examiners was not significant ($f_{(4,76)}=1.5$ & $p=0.209$). For better evaluation of interaction, liner curve has been showed in Table 3.

Considering Figure 3, two kinds of changes, inter-examiner and between-examiner will be explained:

Inter-examiner changes: as can be seen for each three examiner, the scores of three tests are almost on a straight line. This means that all three examiners were able to operate the device uniformly. Inter-examiner changes was about half a degree and non-significant. Between-examiner changes: in first, second and third times the changes test between examiners were 0.5, 1.5 and 1 degree, respectively and was non-significant. Overall, the three examiners were able to operate the device in reliable condition and to produce the same scores.

Table 5 shows the information related to correlation between proposed method and reference method of X-ray that correlation is high level and significant. Figure 4 shows scatter plot of proposed method with referencemethod of X-ray. Survey of this curve indicates that the performance of the proposed method is accurate.

Table 1: Statistical descriptions of sociological index of two test groups

The mean and standard deviation of the group of 15 people	The mean and standard deviation of the group of 31 people	Variables
24.47±3.05	25.33±2.79	Age (years)
76.22±8.42	72.52±7.67	Weight (Kg)
172.50±8.42	177.33±3.43	Height (cm)

Table 2: Objectivity coefficient of the device in measurement of lumber lordosis angle

		F Test with True Value Zero		Confidence 0.95%	
The lumbar lordosis angle	Cronbach's alpha	Lower Limit	Upper Limit	F	Sig.
First time	0.964	0.927	0.985	81.84	0.000
Second time	0.970	0.936	0.987	98.78	0.000
Third time	0.955	0.909	0.981	65.31	0.000
Middle three	0.973	0.945	0.988	110.27	0.000

Table 3: Reliability coefficient of device in measurement of lumbar lordosis angle

		F Test with True Value Zero		Confidence 0.95%	
The lumbar lordosis angle	Cronbach's alpha	Lower Limit	Upper Limit	F	Sig.
1	0.978	0.954	0.990	132.7	0.000
2	0.987	0.972	0.994	224.5	0.000
3	0.982	0.963	0.992	167.6	0.000

Table 4: Within-group effects

Source of Change	Sum of squares	df	Mean square of	F	P
Testers	33.84	2	19.921	2.39	0.113
Error	27.05	38	7.328		
Test time	4.67	2	2.347	1.14	0.331
Error	78.33	38	2.061		
Tester*time	8.69	4	2.172	1.50	0.209
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Table 5: Pearson Test Results For the relationship between Angle X-ray method and the proposed method

Methods	r (The correlation coefficient)	Significance level (two-tailed)
X-ray	0.955**	0.001
Proposed method		

DISCUSSION AND CONCLUSION

The routine evaluation to asses accuracy of made device is so that first several times measuring is done by designed device and other time measurement is done by reference device. Then the correlation coefficient and mean of two device are compared. Statistical analysis of Table 2 shows that objectivity of each device is at least 0.95 in per time measuring and the objectivity between mean of the device is about 0.97. These results show that all of examiners learned soon how to operate the device and it requires no special training to work with. Consequently, objectivity of the proposed method is high and in acceptable level. statistical analysis (Table 3) showed that reliability of each examiner is at least 0.97. The analysis proved that there is no need to measure each participant three times to reach constant value and one time measurement is adequate.consequently of the proposed method is high and acceptable. Statistical analysis (Table 5) showed that correlation between proposed method and x-ray method is 0.95 and it demonstrates the high validity of proposed method in measurement of lumber lordasis angle.

Rational reasons of high results of above statistical analysis can be attributed to high accuracy of the device and standardization of test conditions. Also in proposed method, the body of participants is not touched by the examiner and it vanish many sources of error. Examiner expectation does not affect on results. High accuracy of proposed method makes it possible to use this method in conjunction with other non-invasive methods. This device can be used in other medical clinics for diagnosis of lumbar lordasis abnormal improvement trend according to the angles diagnosis. Also, this device can be replaced for costly device of spinal mouse in clinics. Also different universities can take advantages of this new method with assigning less cost in comparison with Spinal Mouse device.

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