Is Spinal Mouse a Valid Tool in Assessing Spinal Deviation in Patients with Lumbar Spondylosis?

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ABSTRACT

Background: Spinal deformity is common among the general population; it affects about 27.3% of all deformities related to musculoskeletal system which progressed over time and exerts significant effect on the health-related quality of life. Assessment of spinal deformities almost depends on radiological methods with no respect to their harmful effect. Spinal Mouse (SM) is radiation free device used for assessment of spinal deformities, segmental and global range of motion of spine. **Objective**: To investigate the concurrent validity of spinal mouse device in assessing sagittal plane deviation in both thoracic and lumbar regions. **Methods:** Fifty-five patients diagnosed with lumbar spondylosis participated in the study. Their ages ranged from 40-60 years. All subjects were evaluated clinically and radiologically. The examiner performed assessments using spinal mouse and took a radiological film to measure the sagittal spinal deviations either kyphosis in thoracic region or hyper or hypo-lordosis in the lumbar region. **Results**: There was significant correlation between measures of thoracic spinal deformity using both spinal mouse and X ray methods (p =0.001), (r= 0.918). There was a significant correlation between measures of lumbar spinal deformity using both spinal mouse and X ray methods (p =0.000), (r= 0.827). **Conclusion:** Spinal mouse was a valid device used for measurement of thoracic and lumbar spinal deformity in sagittal plane with no harmful effect especially in individuals with lumbar spondylosis and spinal deviations that need regular assessment and follow up.

Keywords: Lumbar spondylosis, Spinal deformity, Spinal mouse, Validity, Concurrent validity.

INTRODUCTION

Spinal deformity is common among the general population it affects about 27.3% of all deformities related to musculoskeletal system, it is an abnormality in the shape, alignment, or formation of the vertebral column in frontal and sagittal planes of the spine, it occurs in 27.3% of the population [(1)]**.** There are several forms of spinal deviations such as degenerative scoliosis, kyphosis and hyper lordotic or flatting curve, when the spine deviated, the rest of the body reacts as Muscles strain, pumping of lungs will be harder, and simple functions as walking will be difficult.

Scoliosis is presented with 1.5% to 6.3% of the total number of spinal deformities [(2,3)] the remaining part belongs to deformities of sagittal plane as hyper kyphosis hyper or hypo lordosis [(4)]**.** If

these deformities not treated it can lead to functional disorders of the respiratory and cardio-vascular systems, and pain, which, in turn, reduce the physical condition and working capacity of the individual and increasing the economic and social costs due to treatment costs, loss of the quality of work and work-related disorders [5,6]. Postural correction is an important element of physical therapy management of patients with back dysfunction. Although the relationship between posture and back pain is largely undefined, it has been proposed that end result of sitting and standing postures, were shown to be associated with changing in muscle activation patterns [7,8,9,10] that put excessive stresses on the passive spinal structures including ligaments, disks and facet joint, capsules and could potentially pose a risk to the progression of back complain [11].

The dependance on clinical examination alone has many limitations, as subjective participation of the observer and the lack of many important qualitative measurement data in each evaluation. also, the radiography is of high quality in assessing spinal deformity but, it is with a high dose of radiation, and it cannot be used for another trial in a period less than 6-12 months [12].

So, there is a need to assess spinal deformations with a safe and more objective tool using new technical devices for spinal curve measurement in population with lumbar spondylosis.

Several different tools, using several technologies of measurement, are used nowadays for the assessment of spinal mobility in many studies concerning for low back dysfunction and treatment [13,14]. Some of these devices show the joint mobility from start and end positions, others, constantly screen and record the alteration of the spinal curves through its range of motion or during the performing of specific activities [14].

The spinal mouse (SM) was evaluated in calculating the spinal curves together with total and segmental spinal mobility [15]. Also, the validity of the SM device in assessing lumbar flexion in symptomatic patients were assessed in contrast to lateral radiography in neutral and full spinal flexion position and Spinal Mouse [16]; however, they did not assess any frontal deviation of the spine between these two methods. Radiographic evaluation had been used for many years to assess sagittal and frontal spinal deviation, although the high radiation dose for application in clinical practice, so, the current study wanted to assess the validity of SM.

Many studies had investigated the validity of spinal mouse to assess spinal deformities on idiopathic scoliosis, thoracic kyphosis and lumbar lordosis, sedentary workers and asymptomatic subjects. This study aimed to investigate the validity of spinal mouse in the assessment of spinal deviation in patient with lumbar spondylosis.

Objective

To investigate the concurrent validity of spinal mouse device in assessing sagittal plane deviation in both thoracic and lumbar regions.

Methods

Study design

Double blinded observational validation study (Patients were blinded to the assessment and research assistant who performed the assessment of all patients was blinded). A group of 55 participants

diagnosed with spinal spondylosis aged from 40-60 years were enrolled in the study after they signed a consent form. The research protocol was accepted by the local institutional Committee of Medical Ethics in the faculty of physical therapy, Cairo university. The participants have signed informed consent to start the practical part of the study. The study was conducted at the research lab in faculty of physical therapy and radiological departments in faculty of physical therapy at Delta university for science and technology, Dakahlia governorate, Egypt 2024.

Participants

Fifty-five patients of both genders with their age ranged from 40-60 years old diagnosed as lumbar spondylosis with sagittal plane spinal deviation as hyper kyphosis (cobb angle > 40°) or hyper lordosis (cobb angle > 30°) or hypo lordosis (cobb angle < 30°).Objective assessment was performed by radiologist who toke full lateral view of spinal column with x ray and physiotherapist with other observer who performed a spinal deviation assessment with spinal mouse (SM) device.

Sample size calculation:

The sample size was calculated with good statistical power to test the reliability of this research, the probability of obtaining the desired precision (assurance probability) was set at 50%. The suspected true ICC was set at 0.8 and the width of the Confidence Interval (CI) was kept at 0.2, then the calculation was made according to the reported equation 17 and the numbers of assessment were set at K= 2 the required samples size is 55.

Instrumentation and Measurement procedures:

1. **Spinal mouse device**

Records of spinal mobility were conducted by using spinal mouse device, a hand-held, computer-assisted electromechanical tool used to assess spinal deviations in many positions, it provided a precise data on spine geometry to document spinal deviation progression and treatment success [(18)]**.** It is a sophisticated measuring device that run along the spinal column with measuring wheel tracking the spine contour, the tool was applied through the midline of the back with a starting point at the seven cervical spinous process and an ending point at the third sacral spinous point at superior edge of the anal crease. The examiner highlighted these landmarks by palpating them and making markers using a cosmetic pencil. It has two moving wheels that run across the back and the readings were recorded that were transferred to a database, using a personal computer with a special software. Data were sampled for each 1.3 mm as the device was moved along the back, with a frequency of 150 H [(19)]**.**

Firstly, all participants received enough explanation on the procedure by the examiner and how to use and deal with it to prevent of faulty results and wrong reports from SM device, then they well informed about software instruction, then every participant took off his shirts and stood in front of the examiner by his back, the software on portable laptop or computer was prepared for assessment procedure, the participant's arms kept hanging freely on either sides of the body, Each participant focused on a fixed object in front of him and to maintain the stable posture 20, then the spinal mouse was tracked along the midline of the spine started at the spinous process of C7 and finished at the vertebrae sacral support (S3), the SM was guided slowly along the spine with both of device wheels remained in contact with the skin throughout the recording, before lifting the SM off the skin the

examiner stopped the recording by pressing the left SM button, a short tone was heard for confirming that data has been fully transferred to the PC. The examiner then palpated the back, highlighted the landmarks on the skin, and applied the assessment in the posture previously mentioned [21] as shown in figure (1).

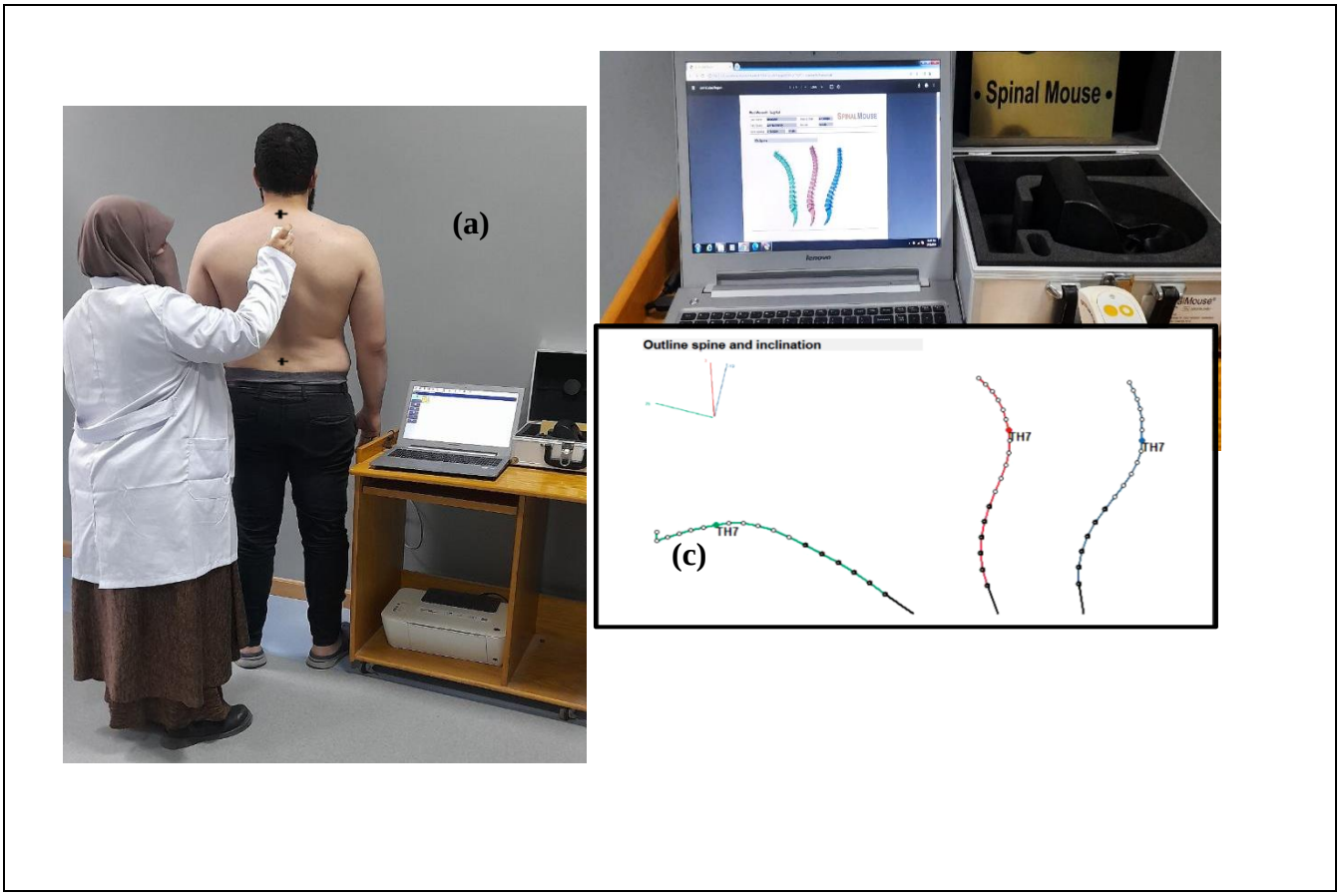

Fig (1): (a) The examiner's thumb guided spinal mouse along the spine, (b) Spinal mouse unit and operating system, (c) SM report.

The SM program uses a very complex algorithm (intelligent recursive algorithm) allowing the measurement of the normal curvature, global and segmental ranges of motion of the spine and also good detection of spinal deviation through measuring scoliosis, kyphosis and lordosis angles shown on report on the computer display, the following figure show example of SM report exploring required spinal deviation angles with anther data collected as shown in figure (2).

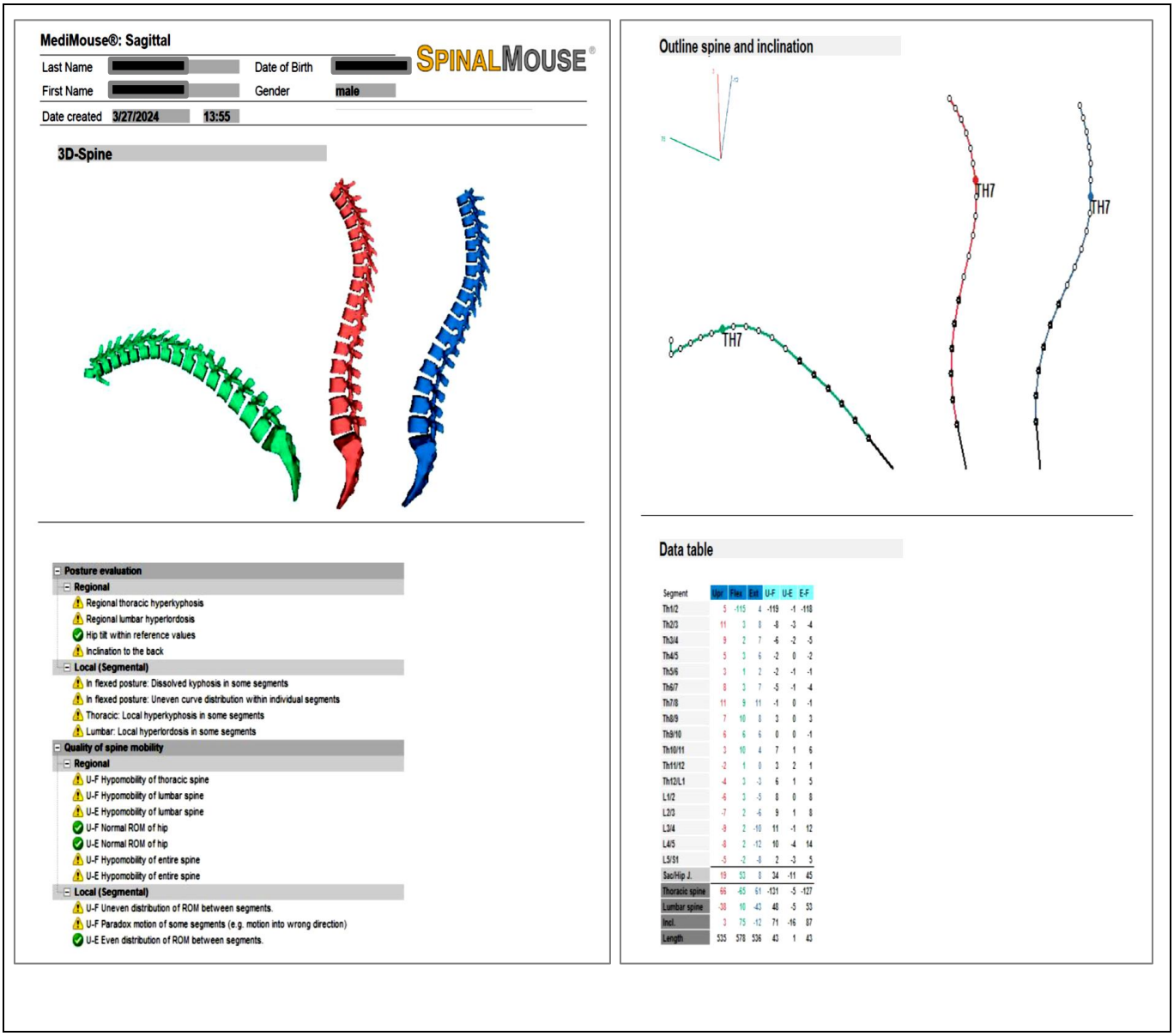

Fig (2): spinal mouse report

2. Radiographic evaluation:

All the included patients signed a consent form then finished the spinal mouse measurement, after that they were allowed to take the radiograph record of their back. The X-ray method was used to measure the lordosis, kyphosis angles as standard method of spinal deviation assessment [(22)]. A standardized radiographic assessment has been done for all patients with radiological film for lateral aspect of spine. In this technique patient stood on a surface on which the feet place was marked with bare footed, then followed upright and erect position, but relaxed, with their knees were fully extended in a natural and comfortable position then the radiologist tokes the full spine X-ray photo and extracted all curvature abnormalities found through the Cobb method.

Statistical analysis

The data obtained was statistically analyzed using statistical package of social sciences (SPSS) for Windows, version 26 (SPSS, Inc., Chicago, IL), the statistical significance level (a) was set at 0.05 when evaluating test results.

The demographic and clinical features and measurement results of the participants as age, weight, height, BMI, spinal deviation and also for all measured variables was expressed as descriptive statistical data (percentage, mean, standard deviation min– max values, and range).

Ethical Approval

Before conducting the study, the institutional review board of the Faculty of Physical Therapy, Cairo University, Egypt accepted our procedures. All participants signed a consent form after thorough explanation of the procedure. They are aware that they can withdraw quit taking part in the study at any time. The study followed the regulations specified by the Helsinki Declaration for human beings.

Results

Patients' Demographic data

Fifty-five participants diagnosed as lumbar spondylosis with sagittal spinal deviations who were enrolled when they met the inclusion and exclusion criteria, they were known about the benefits when engaging this research work, focusing on their ability to drop out from research at any time, and informed them about the confidentiality of their data Participants were aged between 40 - 60 years.

The descriptive statistics for all participants were calculated as follows: The mean and standard deviation (SD) regarding age, weight, height, and body mass index (BMI) were 50.22 ± 5.72 years, 81.9 ± 8.56 kilogram, 169.35 ± 7.1 centimeters, and 28.55 ± 2.24 kilogram/ m2. The sample contained 29 men and 26 women as illustrated in table (1)

Table (1): Demographic characteristics of patients participated in the study:

Variables	Age (years)	Height (m)	Weight (kg)	BMI (Kg/m^2)	Gender [N (%)]	
					Male	Female
Participants (55) ($\bar{x}$ ± SD)	50.2 ± 5.7	169.4 ± 7.1	81.9 ± 8.6	28.6 ± 2.2	29 (52.7 %)	26 (47.3 %)

* $\bar{x}$ = Mean *SD= Standard deviation,

The primary outcome measures in this study were correlation between measures of spinal deviations angles using spinal mouse and X rays' angle for thoracic and lumbar region. The Shapiro-Kolmogorov test was used to assess the normal distribution of collected data of both thoracic and lumbar deviation in sagittal plane and the Pearson correlation test was used to measure the correlation between collected data from the both methods of assessment, the results showed a normal distribution of the collected data (p = .200*) as shown in table (2).

Table (2): Testing normal distribution of collected spinal mouse and radiography measures of spinal deviations of both thoracic and lumbar regions:

Tests of Normality of thoracic deviation from spinal mouse							
	Kolmogorov-Smirnov[b]				**Shapiro-Wilk**		
	Thoracic 2nd reading	**Statistic**	**DF**	**Sig**	**Statistic**	**DF**	**Sig**
Thoracic 1st reading	**47**	**0.231**	**55**	**.200***	**.881**	**55**	**.314**
Tests of Normality of lumbar deviation from spinal mouse							
	Kolmogorov-Smirnov[b]				**Shapiro-Wilk**		
	Lumbar 2nd reading	**Statistic**	**DF**	**Sig**	**Statistic**	**DF**	**Sig**
Lumbar 1st reading	**42**	**0.261**	**55**	**.200***	**.807**	**55**	**.093**
Tests of Normality of thoracic and lumbar deviation of Radiography							
	Kolmogorov-Smirnov[b]			Shapiro-Wilk			
	Statistic	**DF**	**Sig**	**Statistic**	**DF**	**Sig**	
Thoracic (X rays)	**0.19**	**55**	**0.61**	**0.955**	**55**	**0.037**	
Lumbar (X rays)	**0.067**	**55**	**0.200**	**0.987**	**55**	**0.803**	

Concurrent validity of the spinal mouse for spinal deviation measures in sagittal plane for both thoracic and lumbar regions using radiographic assessment:

Regarding the population with lumbar spondylosis with spinal deviation in sagittal plane, there was strong positive significant correlation between the reading of SM and Cobb's angle using Xray for thoracic region ($p = 0.000$, $r=0.918$) and strong positive significant correlation between the reading of SM and Cobb's angle using Xray for lumbar region ($p = 0.000$, $r=0.827$) as shown in table (3).

Table 3: Results of spinal mouse reading and radiological assessment for illustration of concurrent validity of spinal mouse:

Concurrent validity of spinal mouse for measuring sagittal plane thoracic deviation				
	Thoracic (Xray)	**r value**	**p value**	**95% Confidence Intervals**
Spinal mouse reading for Thoracic		**0.918**	**0.001****	**0.863 -0.951**
Concurrent validity of spinal mouse for measuring sagittal plane lumbar deviation				
	Lumbar (Xray)	**r value**	**p value**	**95% Confidence Intervals**
Spinal mouse reading for Lumbar		**0.827**	**0.001****	**0.720 -0.896**

Discussion

The present study was conducted to evaluate the concurrent validity of spinal mouse in assessing spinal deformities in sagittal plane alignment in patients with lumbar spondylosis.

The finding of this study revealed that spinal mouse device is a valid measuring method and its software is applicable with significance for assessment of spinal deformities in the older population diagnosed with lumbar spondylosis. It is known that the standard assessment way for the posture and deformation of the spinal column is the X-Ray [(23)].

In the recent years different trials were conducted to develop new safe methods or tools to evaluate the morphology of the back and its mobility [(24,25)]. The need to develop new methods was to prevent the risks associated radiation exposure in standard radiographs used with different back disorders [(26)]. Spinal mouse is a new electromechanical external tool that is connected to a personal computer with special software to display the recorded data.

The validity of SM was examined in a study conducted by Guermazi et al., (2006) [(27)] to assess trunk flexion against standard radiography, and they concluded that SM has a good metrological property to assess segmental and total lumbar motions during trunk flexion, except for the segmental motion of L5-S1. In the current study we compare the spinal deviation measurement conducted in the sagittal plane with the SM device with that gained by a routine lateral radiographic examination. According to authors knowledge it is the first study that assess the validation of SM device in detecting spinal deviation using the radiography as a standard for comparison for sagittal plane in patients with lumbar spondylosis. The results of the current study confirmed a good/high Spinal Mouse sagittal plane to measure spinal deviation.

The results of our study revealed that spinal mouse device is a valid measuring method, and its software is applicable with significance for assessment of spinal deformities in the older population diagnosed with lumbar spondylosis. It is known that the standard assessment way for the posture and deformation of the spinal column is the X-Ray [(28)]. However, in case of lumbar spondylosis, elderly patients require frequent radiologic assessment of their spine alignment and follow up without concerning to the negative effects of radiation, such as lung, breast and internal organs cancer and leukemia [(29)].

The attributions of the results of the current study were in agreement the study conducted by Fadaee et al., (2017) [(30)], which evaluated the validity of SM compared with cobb method in radiograph to measure the thoracic kyphosis and lumbar lordosis angles, and The spinal mouse device shows desirable validity in measuring angle values of thoracic kyphosis (r=0.81, P=0.001) and lumbar lordosis (r=0.86, P=0.001) when compared with radiography images, according to the results of the Pearson correlation coefficient test.

In the current study, the SM was a valid assessment tool for measuring the spinal deviation in lumbar spondylosis patients, these results came in agreement with as study conducted by Yousefi et al., (2012) [(31)], that compared the validity of non-invasive methods as flexible ruler, spinal mouse, and image processing versus the basic method X-ray radiation and comparing them with each other for measuring thoracic kyphosis and lumbar lordosis angles and concluded that the SM had adequate validity.

Conclusion

The findings of this study concluded that the spinal mouse is a valid, less harmful and practical device with no side effects of the standard radiographic assessment method and it could use in research work, patient's follow-up, screening and in clinical assessment of spine problems especially sagittal plane spinal deviations in lumbar spondylosis patients.

Limitation of study

This study was limited due to small sample size which is considered the optimal number by applying the power analysis which was conducted before starting the study, also the sample group consisted only of lumbar spondylosis patients with sagittal plane deformities.

Recommendations

The results of the present study offered the need for considering the following recommendations:

- Further study will be needed to assess the validity of SM in frontal plane among individuals with lumbar spondylosis with spinal deviations.
- New research will be of value to examine the validity of this noninvasive method of spinal deviation assessment in different spinal musculoskeletal conditions and strengthen the level of evidence for these methods of measurement.

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