

# A novel device to improve sitting posture

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## Abstract

Change to the body position leads to consequent changes in a certain part of the body in relation to other parts and change to the gravity center in relation to the leaning level. These changes, in turn, can cause pain and poor posture. There are different methods of curing kyphosis including surgery, braces, exercises and feedback. One of the methods for improving and controlling posture is to improve the awareness of the patient or to provide them with the benefit of feedback. The device that the researcher used is a kind of biofeedback, which can be placed around the neck like a necklace and is equipped with an accelerometer and a button to control the level of sensitivity and can display error rate, angle and the amount of time the device has been used.

The aim of our study was to determine the validity of the device. Thus the movement analyzer device was used as the standard to which the device activity was compared; the angle displayed on the device was compared with the angle offered by the movement analyzer device in two stages also. In the first stage all data obtained from the angle displayed on the device was compared with the angle offered by the movement analyzer device and the Intra Class Correlation (ICC) and their correlation coefficients were compared. At the next stage, the data was classified into three categories: flexion, extension and hyper-extension; and the ICC and correlation coefficients were studied at all three postures and with a 14-data average. Investigation of both models reviewed showed that generally ICC of the device is

0.995 (0.994, 0.995) and the correlation coefficients is 0.999. The results of all studies proved the general consistency of the gained results through both methods, at all levels and averages.

**Key words:** kyphosis, validity, necklace, feedback, biofeedback, posture

## Introduction

Nowadays people are very often using computers. Prolonged sitting with the same slouch posture, especially in office workers, makes them susceptible to back pain or injury. This kyphotic posture will result in discomfort, pain, and changes in thoracic alignment and it will contribute to changes in other parts of the body. Musculoskeletal problems and postural mal-alignments are usually the result of lack of muscle coordination. Weakness on one side can cause tightness in the other muscle (Watkins, 2009). Medical and ergonomic studies indicate that poor sitting and standing postures will contribute to pain in muscles and connective tissues of tendon, ligaments and joint capsule. Some evidence has shown that these symptoms will lead to chronic diseases like rheumatic disorders (Grandjean, 1997). Slump sitting posture will result in relaxation of the spinal stabilizing muscles, which will cause increase in intervertebral disc pressure and increases in the connective tissue loading (O'Sullivan, 2006). One of the postural mal-alignments at thoracic spine is Hyper-kyphosis and one of its causes is poor posture (Lou, 2012). Hyper kyphosis will cause tightness and shortness of muscles at the anterior side of the thorax and it can contribute to rounded shoulders. In contrast, posterior trunk muscles will be weakened by continuous stretching (Scanel, 2003). The thorax has an important role in all thoracic spine movements, including flexion, extension, lateral bending and rotation (Watkins, 2005). Biomechanics of the thoracic spine are different from neck and lumbar spine due to thorax and sternum and these structures help stability and movement control of the thoracic spine (Horton, 2005). Thoracic movements in sagittal plane are being affected by spines, sternum and ribs (Horton 2005). Wedge fracture of thoracic spines will indirectly result in fracture of the sternum (Lund 2001).

There are several methods to manage poor posture such as surgery, bracing, exercise and feedback. Surgical correction of kyphosis is an extensive method and can cause complications (R de Amoreira Gepp, 2013). Braces are not often comfortable and reduce spinal movement (Osman, O., 2015).

Thoracic hyper kyphosis can be corrected by voluntary extension of the thoracic spine (Lovel, 2006). Our necklace like device is an alert system which has an accelerometer and a button to adjust the intensity and shows the rate of error, angle and the amount of time using the device and has a reliability of 0.99% with the movement analysis device and it will help correction of posture by voluntary extension of spinal muscles.

## Method

### Feedback necklace

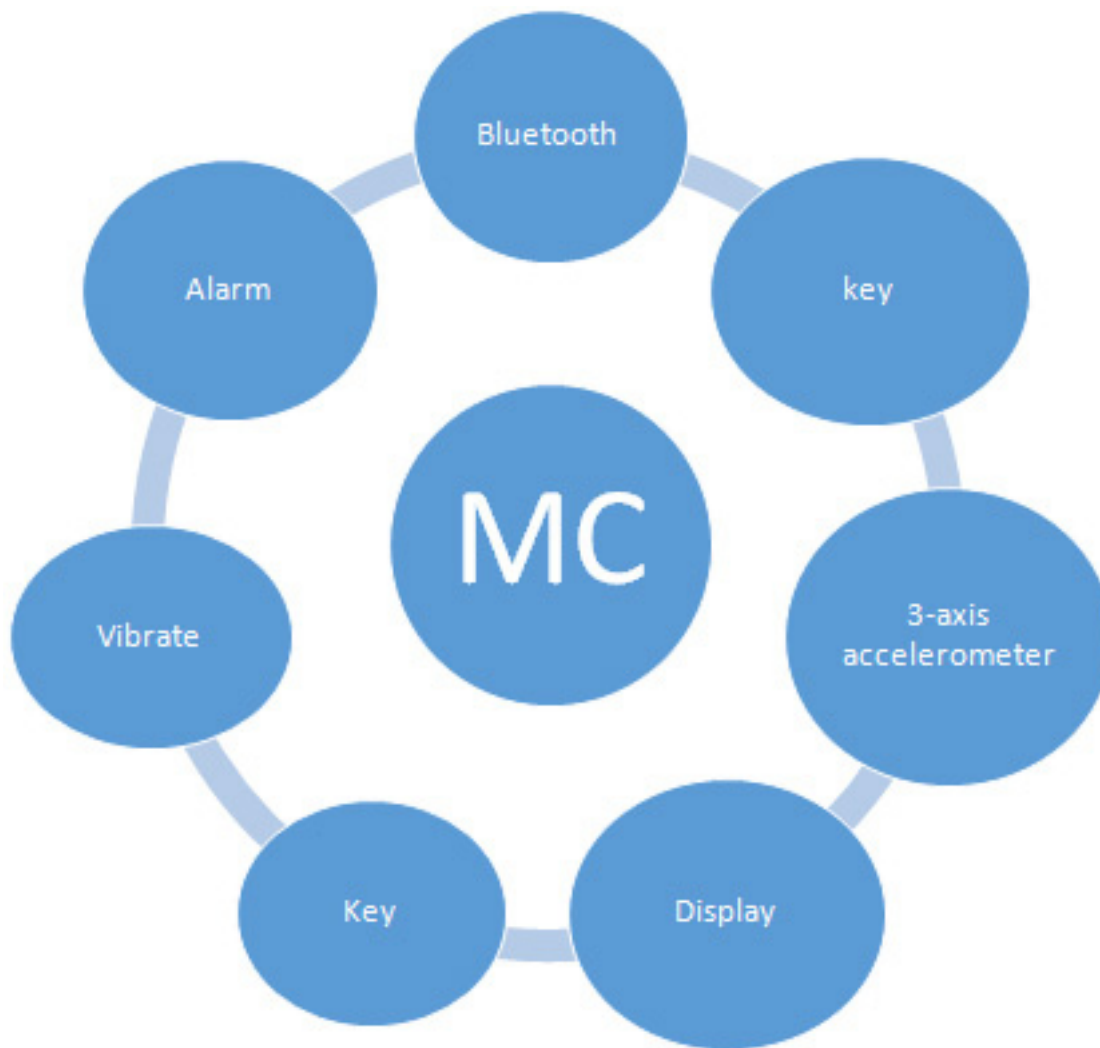
The device we made is a feedback device which can be used like a necklace or by sticking it to the body.



**Image1: Place of installation on the body**

It contains 3-axis analog accelerometer, processor, display, vibration, and battery and a few buttons. It is easy to use and the main function of the device is performed with a key; at one pressure it will be started and by longer pressure it will be stopped. The device will react to pressure by "vibration" or "beeps". The very low energy consumption of the device will help it to continue its activities for a long time (over a month).

For measuring the body angle a three-axis analog accelerometer sensor is used. The output of the sensor can be positioned by internal processor. The output of the device is in voice or vibrate type and the user can choose between them by the two buttons on its sides. The activity of the device is only possible when the person is not moving or walking so it is recommended to use it in an upright or sitting posture, especially when using the computer; in case of a movement, the process will stop. (If you use two devices simultaneously, it will continue its activities, even when moving). Although the device can be set up to correct movement of one plane, such as flexion and extension of the upper trunk and it will not show error while moving from the pelvic girdle forward or backward because it will not change the device's angle is to the ground. To start using the device, it should be set by the physiotherapist in the correct sitting posture; the device will keep the angle to its memory. Each time the user keeps a bad posture for a long time (time can be set by the therapist) the device will alert the user to correct their. In addition, the changes of the angle are also stored. All of the information will be stored on the device, including angles, number of bad postures, the amount of time the device has been used etc. and it can interface with computer software or mobile phone. The therapist can use this information to check and compare the amount of progressions and help the user to further improvements.

**Image 2: Internal components of the device**

The stored information includes:

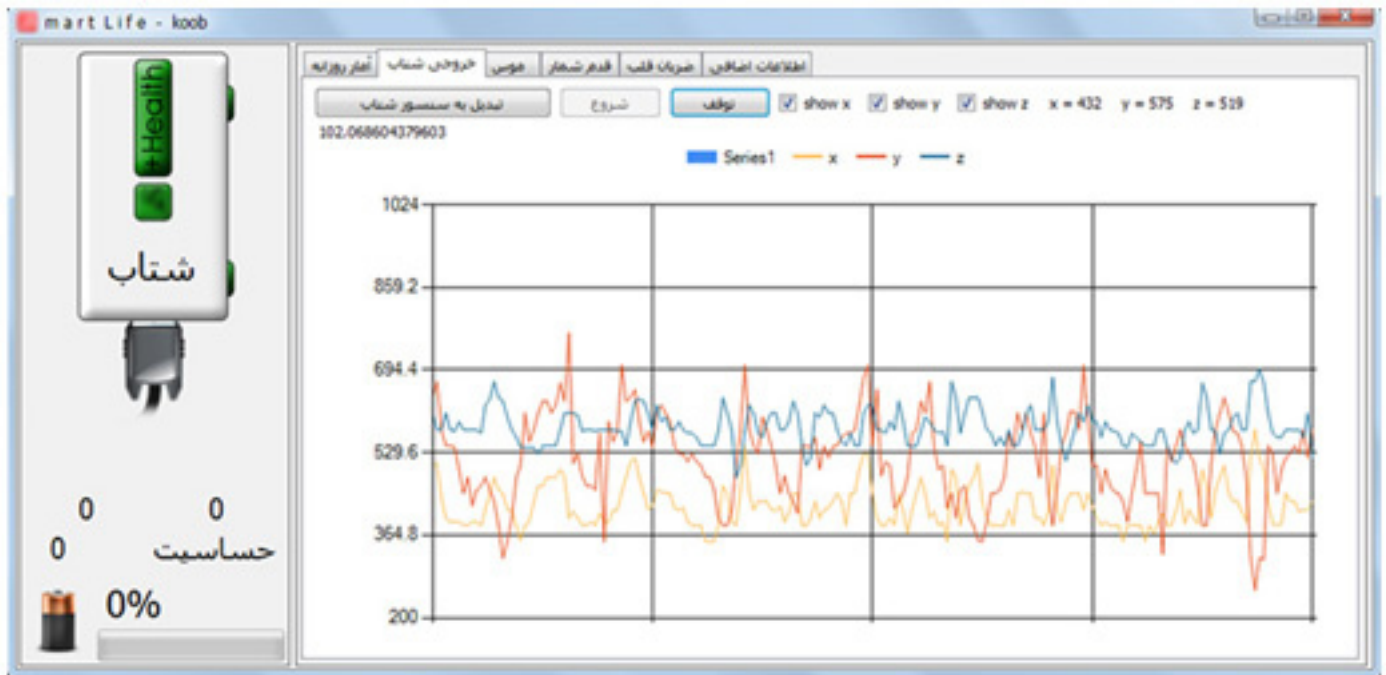
1. The angular moment of any individual when using the device
2. Showing the difference between the original angle and the individual's angle in the form of graphs and the angles
3. The amount of time the device is turned on and being used
4. The amount of individual errors in form of chart
5. The ready to work time
6. The number of second-order errors
7. The number of times the device has continuously been active for more than 10 minutes (or any other optional number).

In addition to monitoring and showing the time of use and the person's errors it will show the angles and the difference of angles as well as errors in the form of numbers and graphs with special software for the user and therapist.

In addition, it is fully customizable and since it has been designed in necklace shape the user can use it easily at any time of the day without causing pain, pressure or drawing any attention that is normally created by a vest or brace and it can be turned off whenever it is not needed.

Regarding the point that the sternum is related to spinal fracture and its stability, it can have an important role in spinal deformities and correction of severe injuries in the sagittal plane. (Horton 2005). Since Tormene and colleagues used their assessment device on the anterior side of the body (Tormene 2012) and because of the sternum role in thoracic movements we used our device in necklace form.

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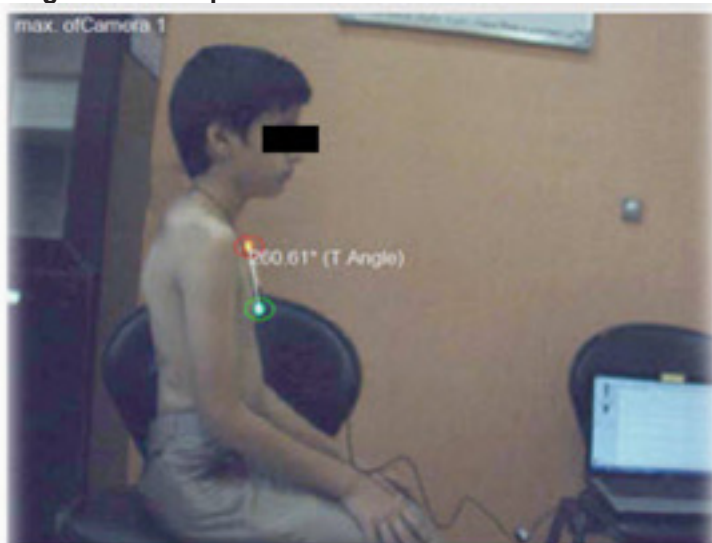
**Image 3: The device's software**

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#### Reliability assessment

At first the device's software was set to measure the angle in a circular pattern. Then to compare the accuracy of device's measurement with an index, we used a Video motion analysis system called Simi Aktisys. The error rate of this device was reported less than 1/6% of the manufacturing company in addition several lots of research have also been carried out with the use of this device. (<http://www.simi.com/en/references/publications.html>)

After filling out the informed consent form by the sample volunteer, he was asked to take off his clothes and the markers were placed on his sternum by the physiotherapist; the red marker was placed at the apex of the bone and the green marker was placed at the top of the xyphoid process. (Image 4)

**Image 4: Sensor places**

These markers can be identified by the camera and the software and the angle they make to the ground will be identified. Then the device was set on the body of the volunteer, and he sat on a table. First the correct flexion and extension movement was practiced by the volunteer and then he was asked to start doing the movements as required. Then the results and the graphs were compared. To ensure, and increasing the error rate, the measurements were repeated three

## Results

To ensure that the angle measurement and the results of the device have reliability the Video motion analysis system, and the data were investigated generally and in the 3 groups, flexion, extension and hyper extension group.

In general there is a correlation coefficient of 0.99 when comparing the two methods; it shows that the device has a very good reliability index.

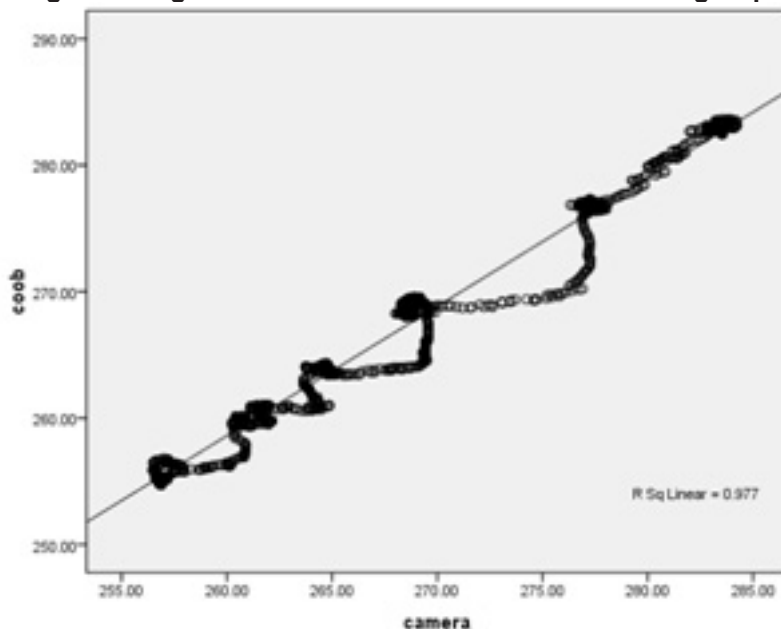
Statistics	r (p-value)	ICC(0/95CI)
Data		
General Data	0/99 (0/00)	0/99 ( 0/99 .0/99)

For data smoothing and prevention of possible adverse disturbances of both methods, they were divided into 3 groups, flexion, extension and hyper extension, then the data of each group was divided into 14 classes.

At each stage, the data were classified into two groups of complete and smooth category. For statistical consistency of the methods, ICC was used and to identify the correlation coefficient, the Pierson correlation coefficient was used. To normalize the data the Kolmogorov–Smirnov test (K–S test or KS test) was used.

The coefficient correlation between the total data in the flexion group was 0.994 (0.994, 0.993) and the coefficient correlation of Pearson showed 0.998, the amount of ICC was (0.999, 0.992) 0.997 and the coefficient correlation showed that 0.996, represents a perfect match of measuring device and movement analysis device. K-S also being the normal distribution of the data is well paved. Image 5 shows the general the distribution of the data at flexion group and image 6 shows homogeneous data distribution in forward flexion.

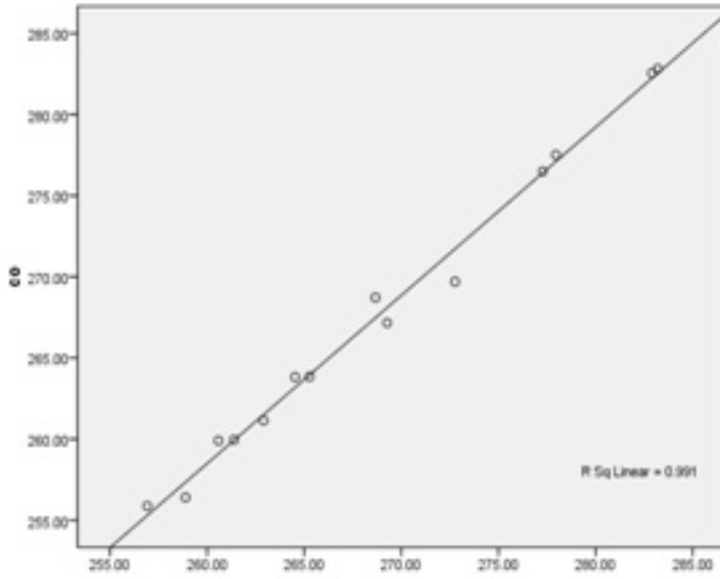
**Image 5: The general distribution of the data at flexion group**



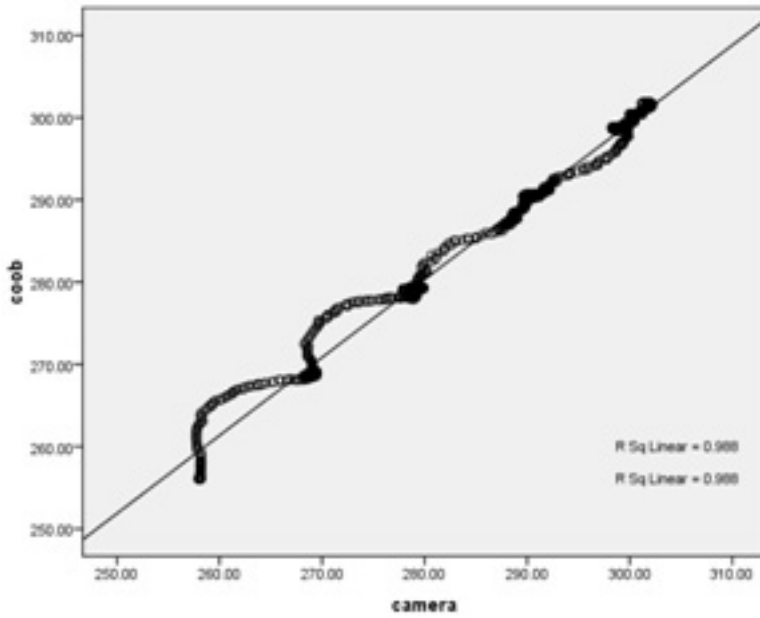
The second group is the extension group, which means extension from flexion movement; the coefficient correlation between the total data in the extension group was 0.997 and the coefficient correlation of Pearson showed 0.994, the amount of ICC was 0.999 and the coefficient correlation showed that as 0. Image 7 shows the general distribution of the data at extension group and image 8 shows homogeneous data distribution in extension.



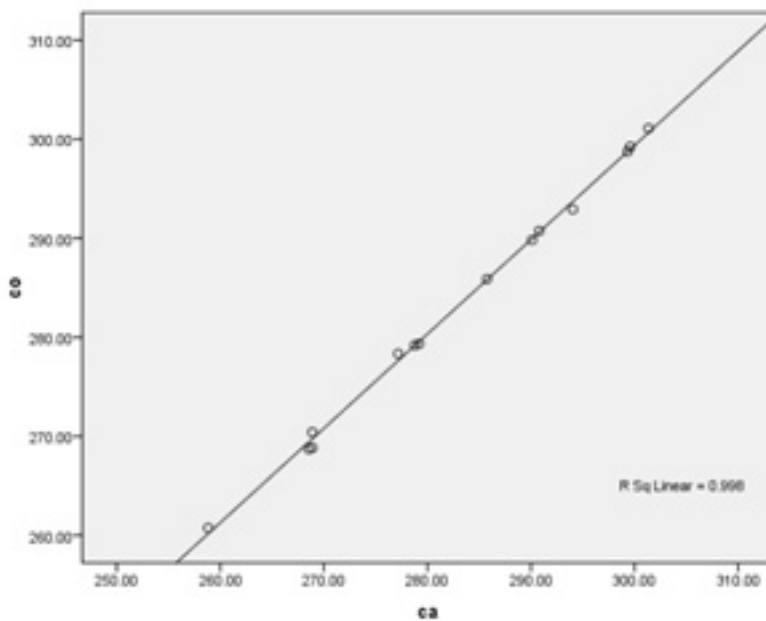
**Image 6: The homogeneous data distribution in flexion**



**Image 7: The general the distribution of the data at extension group**

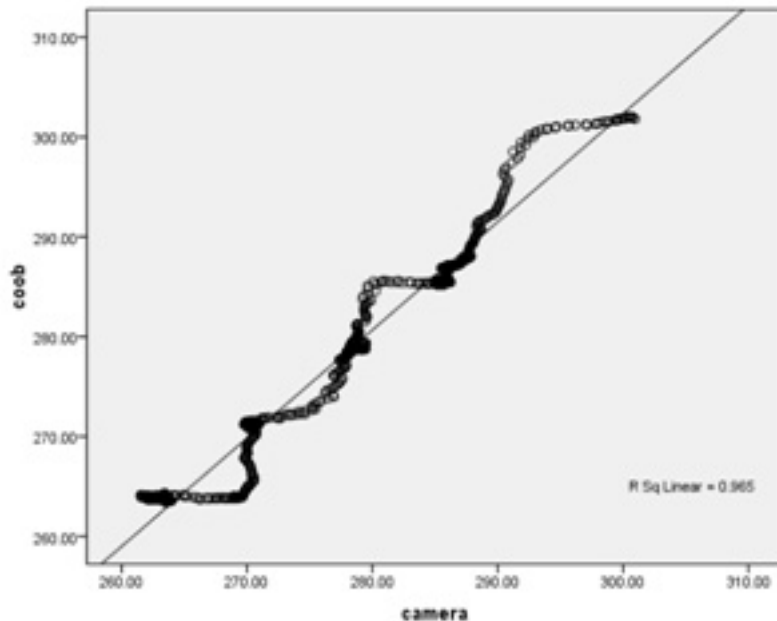


**Image 8: The homogeneous data distribution in flexion**

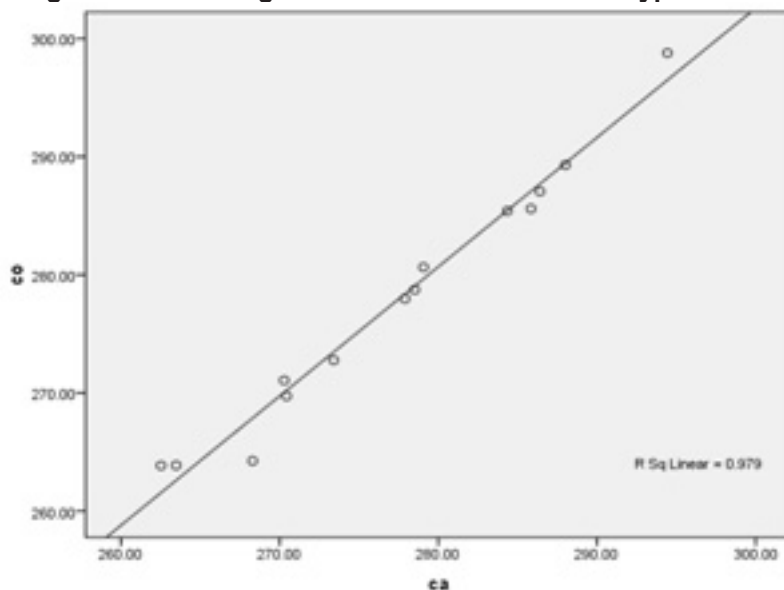


At the last period, the hyper-extension movement was tested and these results were identified. The coefficient correlation between the total data in the hyper extension group was 0.989 and the coefficient correlation of Pearson showed 0.992; the amount of ICC was 0.992 and the coefficient correlation showed that as 0. Image 9 shows the general distribution of the data at hyper- extension group and image 10 shows homogeneous data distribution in hyper- extension.

**Image 9: The general distribution of the data at hyper- extension group**



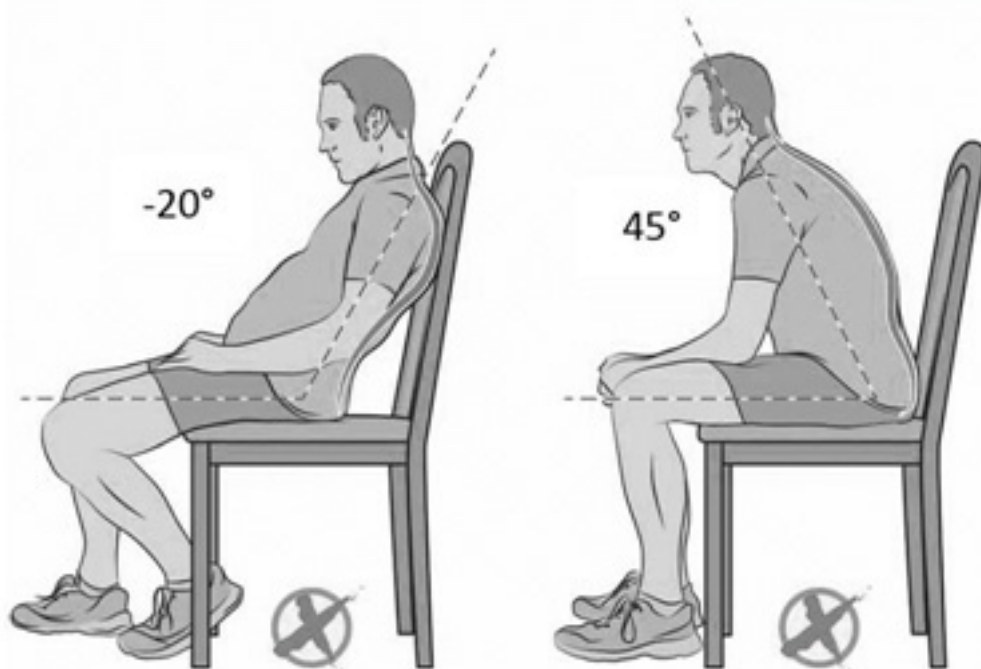
**Image 10: The homogeneous data distribution in hyper- extension**



The overall result shows the exact correlation in both methods and it seems that both devices show the same values and it shows the validity of the device in a motion analysis system and it can be used to assess and correct. When the subject sits in the perfect position that the physiotherapist has chosen the device shows no error, as Image 11 (next page).

**Image 11: The perfect sitting posture by physiotherapist**

If the subject sits in different posture, shown in image 12, the device indicates the bad posture and will vibrate.

**Image 12: Poor posture degrees**

## Discussion

The thorax has an important role in all thoracic movements, including flexion, extension, lateral bending and rotation (Watkins, 2005). As we know the biomechanics of the thoracic spine are different from the lumbar and cervical spine because of the rib cage and sternum and these structures help the stability and movement control of the thoracic spine (Horton, 2005). Horton et al. show that the sagittal plane movements of the thoracic spine are influenced by the sternum and ribs (Horton, 2005). Sternum and Sterno-costal joints have a vital role in the respiration mechanics, but we should not ignore their biomechanical role in thoracic spine fractures and correction of thoracic

spine deformities (Horton, 2005). For example, in 2001 Lund showed that wedge fracture of the thoracic spine will indirectly result in a Sternal fracture (Lund, 2001). Horton et al in 2005 showed that the second effective treatment for kyphosis after removing the disc and its contents is a combination of removing part of the sternum and releasing the sternocostal joints (Horton, 2005). It seems that it can be possible to use sensors in front of the body to assess or correct the kyphotic posture as Tormene et al used sensors in front of the body to measure the thoracic extension (Tormene, 2012) and in Bazarelli et al's research the kyphosis was not measured directly but also changing the angle of the thoracic and lumbar region comparing to neutral position was evaluated (Bazarelli,