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.

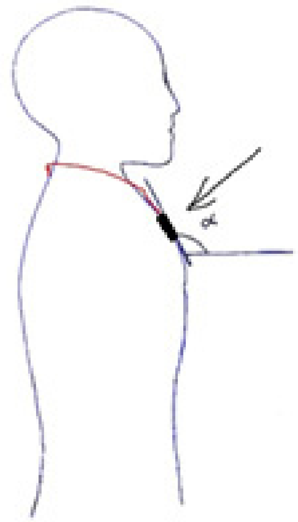
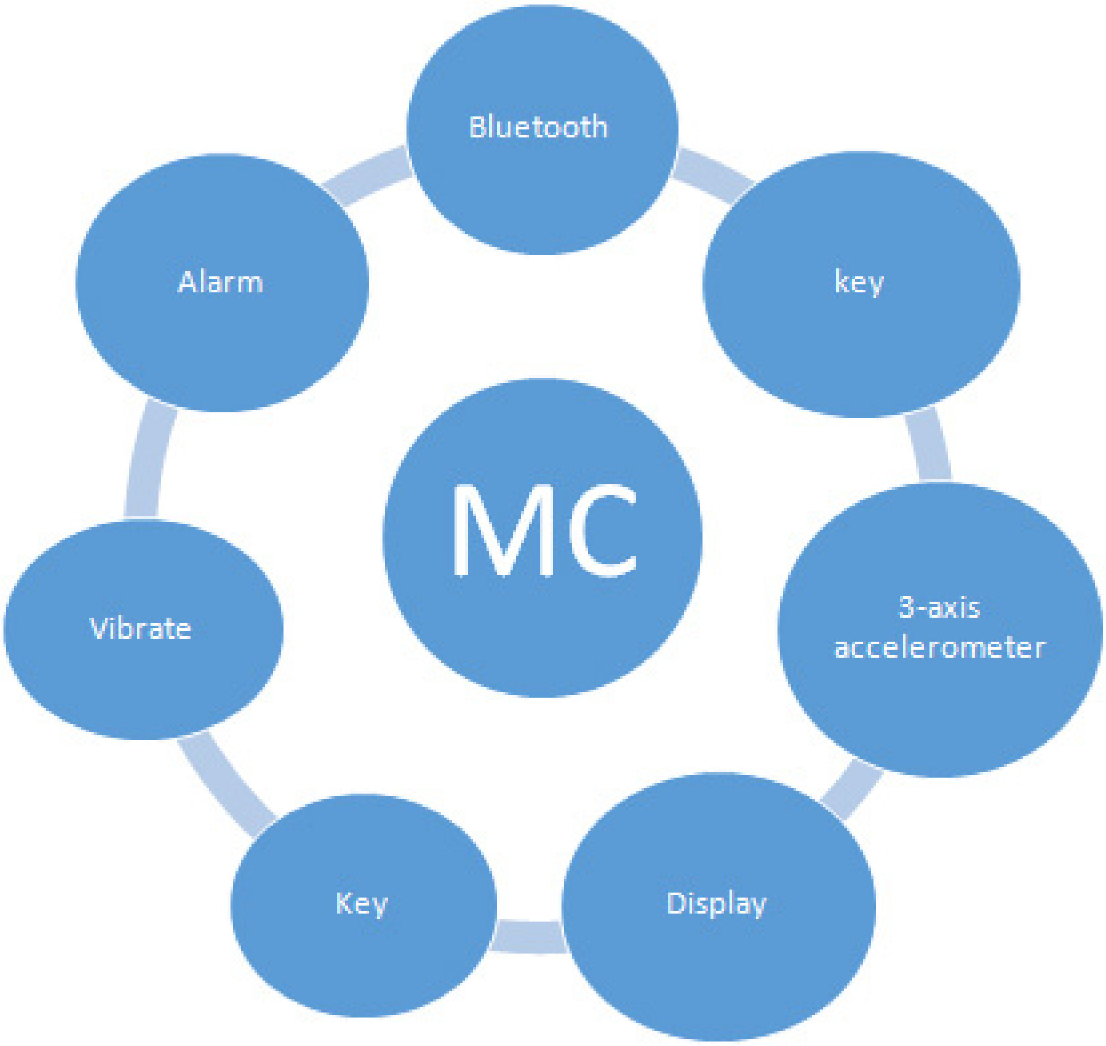


Image1: Place of installation on the body

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 griddle 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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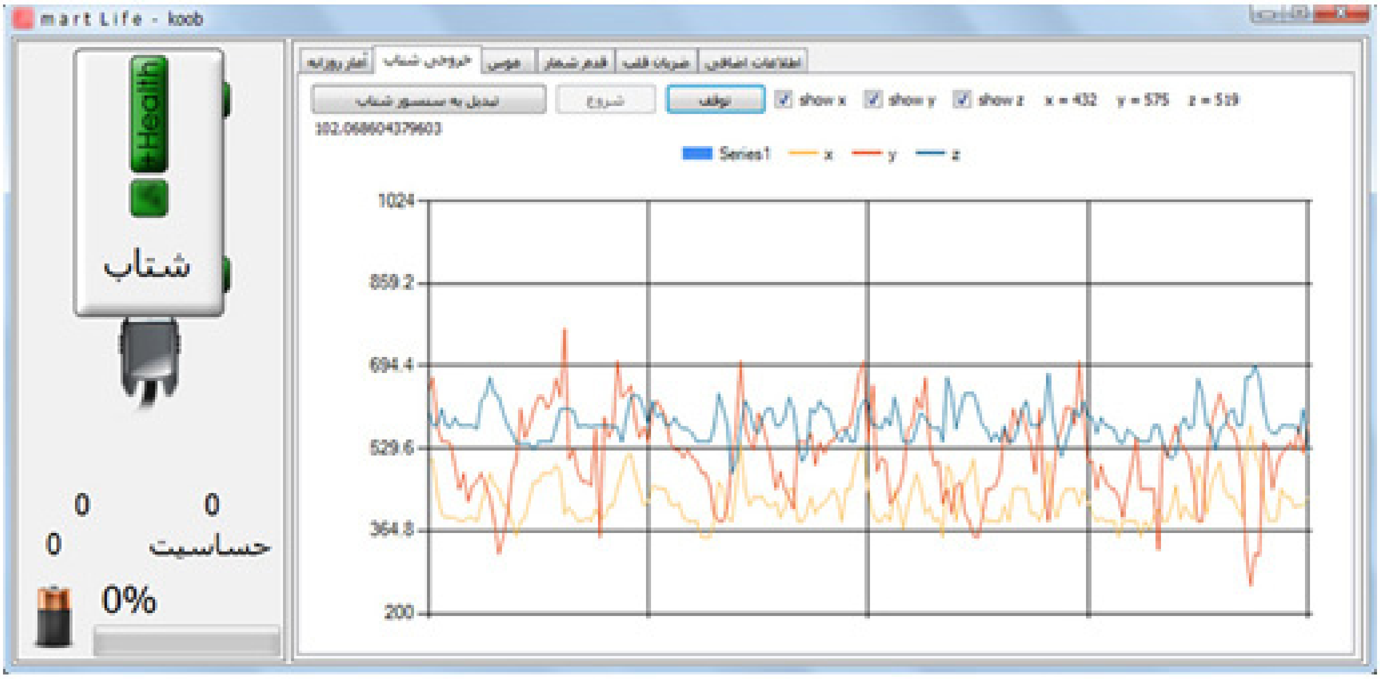
Image 3: The device's software



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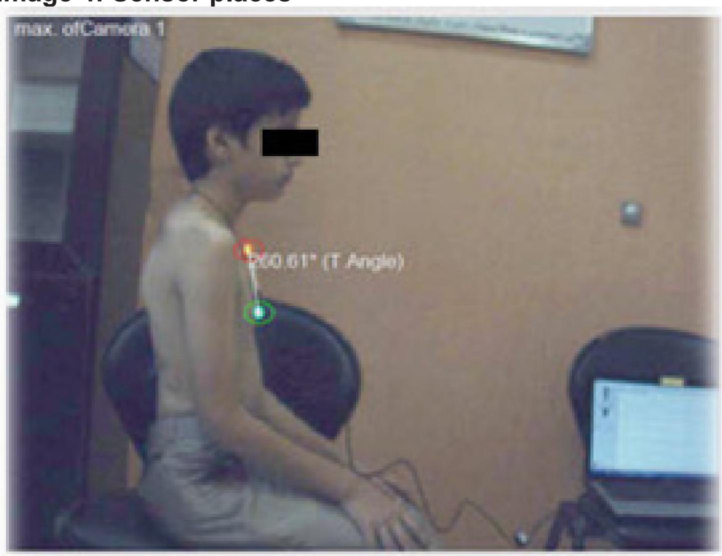
Reliability assessment

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 xyphiod 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.

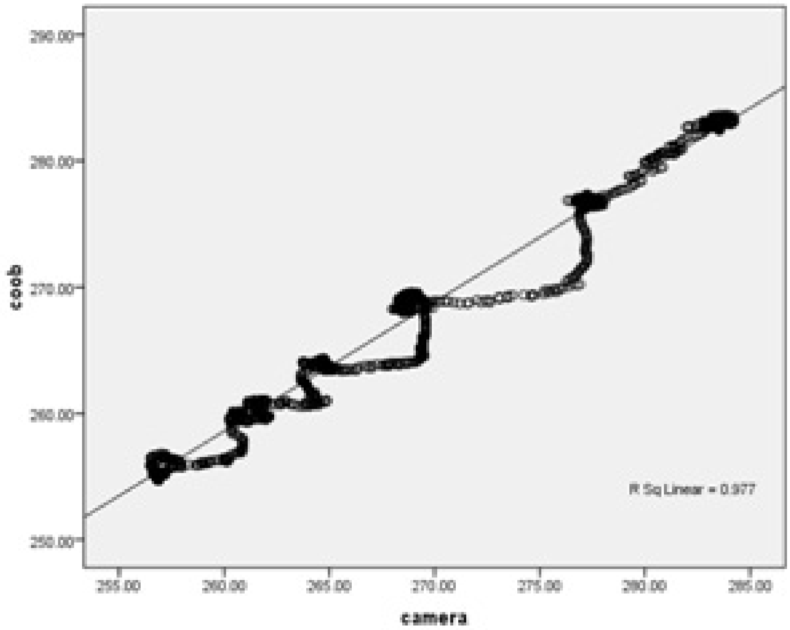
Statistics / Data	r (p-value)	ICC(0/95CI)
General Data	0/99 (0/00)	0/99 (0/99 .0/99)

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

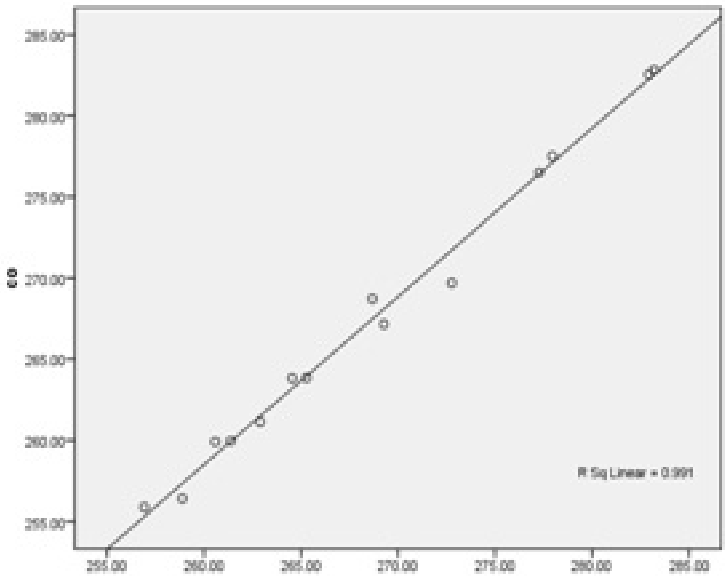


Image 7: The general the distribution of the data at extension group

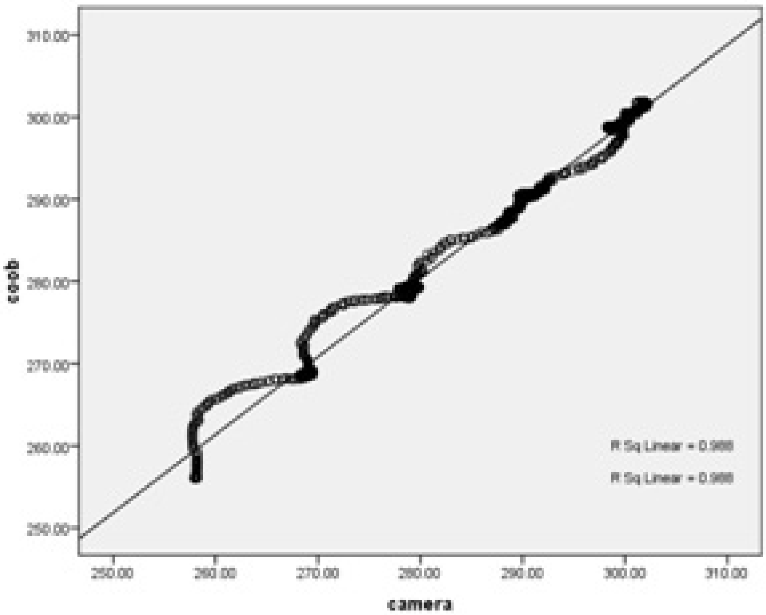
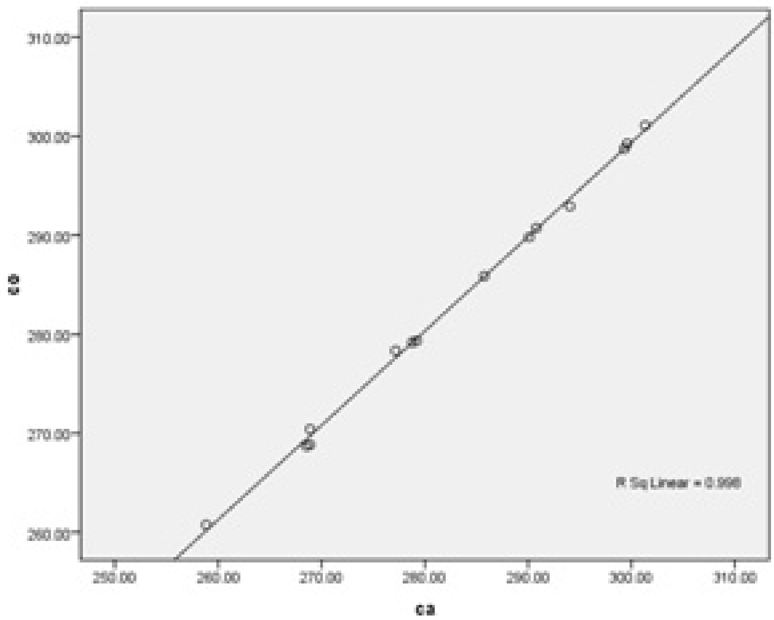


Image 8: The homogeneous data distribution in flexion



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

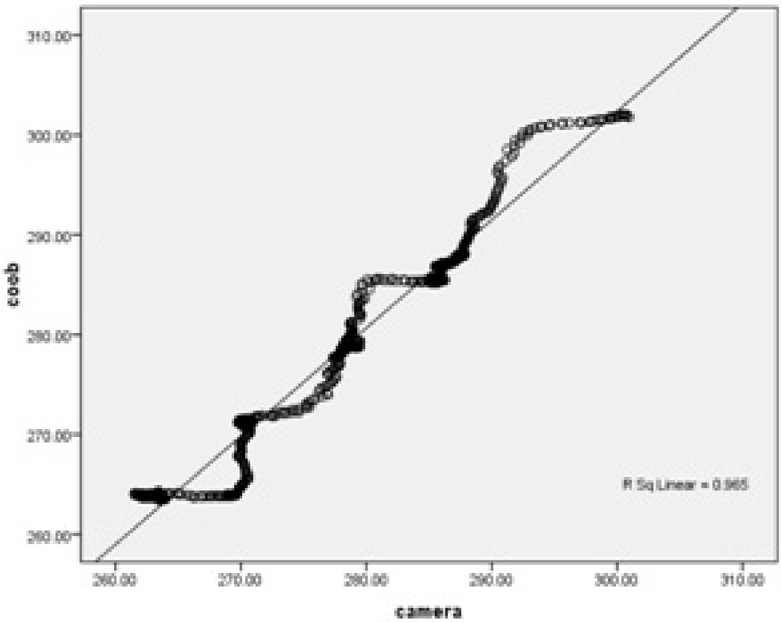
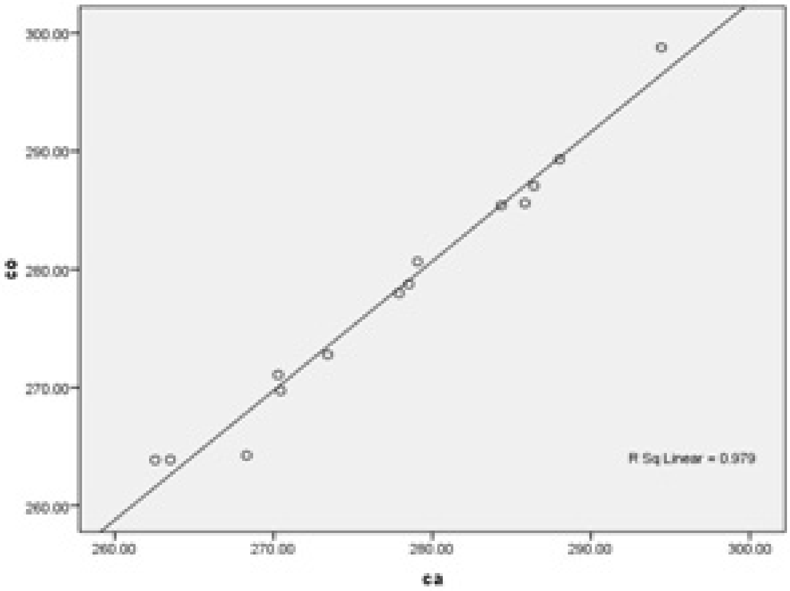
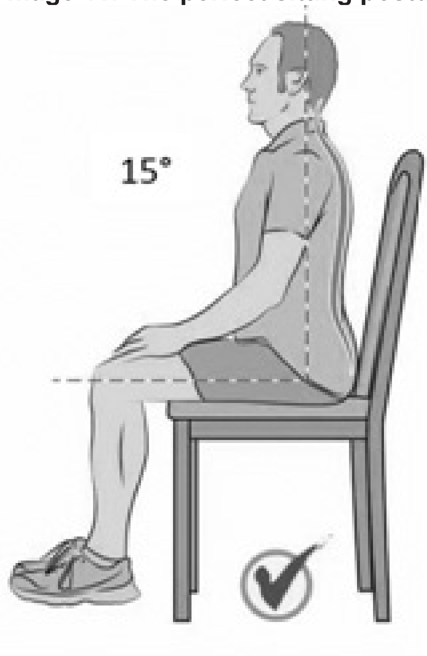


Image 10: The homogeneous data distribution in hyper- extension



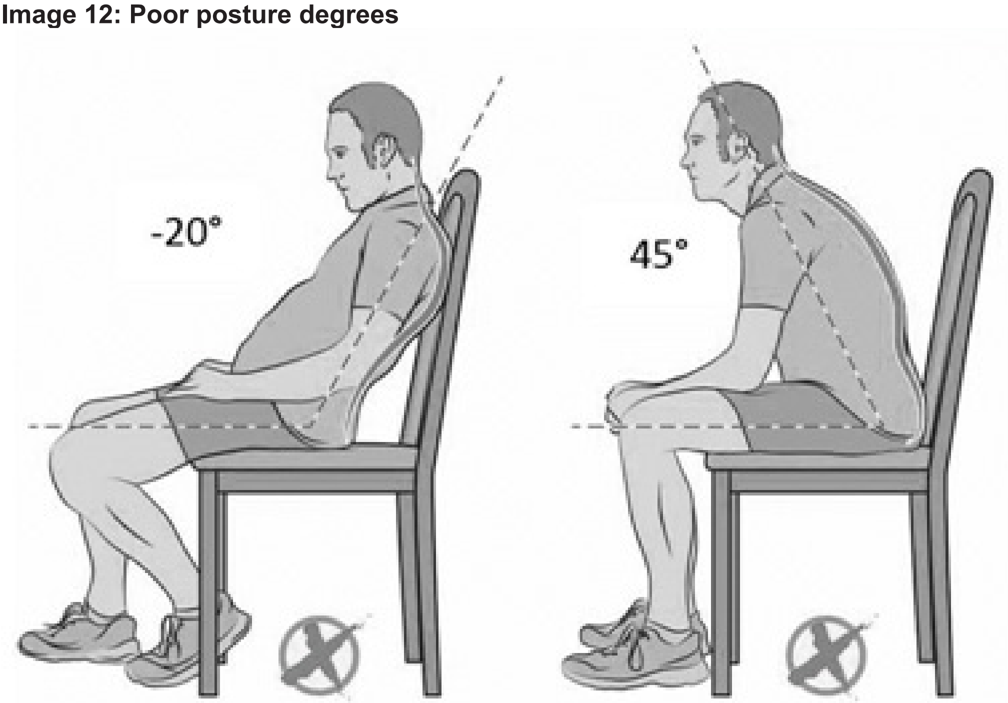
The overall result shows the exact correlation in both methods and it seems that both devices show the same values and it shows the validity of the device in a motion analysis system and it can be used to assess and correct. When the subject sits in the perfect position that the physiotherapist has chosen 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, 2003). Therefore, in this study to determine proper posture we used the sternal angle.

To do this research, first the required software was designed to measure angles. The measured angle is the angle sternum makes radially to make a circle.

To compare the performance and reliability of the device a reference is required. To do this Simi Actisys 1.3 model motion analysis system was used which is a quick and simple way of conducting dynamic movement analyses with the fully automatic tracking of colored LED markers. To perform the test with 95% and 80% statistical power, 14 angles were required. To eliminate the error due to the large number of samples, data were analyzed separately in each part of the graph.

Kolmogorov-Smirnov statistical method was used to determine the distribution of the same data and the same correlation coefficient to determine the function of both methods. The results revealed 99% correlation between the motion analysis system and device and the results were consistent with the results of other investigations. For example, to demonstrate the validity of biofeedback made by Luo and colleagues in 2006 the accelerometer was used. The results of their device were compared with the laboratory accelerometer and the results showed that the innovative device demonstrates 2 degrees of error at any angle of 180 degrees and the mean angle was 6.1 after 3 measurements (Lou, 2006). The designed device looks like a brace which includes three accelerometers and a small micro-computer in one's pocket; the brace size and the location of the sensors was determined by X-rays or a doctor. The cause of 2 degree differentiate may be because of the placing the accelerometers in 3 different places. Our designed device doesn't need particular placement by the doctor or X-rays and everyone can use it easily. The results of another study by Wong et al. in 2008 showed that the laboratory tests of their smart jackets represent the accuracy of 1 to 1.5 degrees with the motion analysis system and the Pearson correlation coefficient obtained by this method was 0.99. The device consists of three sensors, which each consist of accelerometers and gyroscopes and to check the validity of it an accelerometer and motion analysis system was used (Wong, 2008). But their experiment with the motion analysis system was not accomplished on a human subject, but on a moving robotic basis and of course their results are similar to ours. The advantage of our system is its smaller size and more accurate measurement compared to Wong et al.

In another study in the same year Wong et al. noted that built-in sensors can measure body movements and these results are comparable to the motion analysis system and this time they used a large number of sensors in various parts of the body showing their innovative device has 4.3 degrees in the sagittal plane, 6.3 degrees in the coronal plane, and less than 0.829 degrees in flexion and lateral flexion movement difference with the motion analysis system and ICC was 0.999 (Wong, 2008) which seems to be the same with our device.

In 2012, Lou et al.'s device shows 2 ± 2 degrees difference while measuring body angles without movement, 2 ± 3 degrees difference with slow movements and 4 ± 4 degrees difference with fast movement comparing with a motion analysis system and Pearson correlation coefficient obtained in this way was 0.999 (Lou,2012). The device consists of a cable that is placed over the thoracic spine and is connected to the body in the lumbar and shoulder by a long leg brace. They also used human samples in their experiment. The difference made by Lu and colleagues in 2006 and 2012 is that the designed device in 2006 was for children while the new device has no age limit. In addition, 3 accelerometer sensors were used in the construction of the older device, but the new device uses accelerometer and gyroscope at the same time and wearing this new device is easier than the older one and doesn't need a specialist or X-rays.

With the progress of the investigation, one of the most important characteristics is the ease of use and the less visibility of the device to permit easier acceptance by the patient and the treatment to be effective. Advances include: minimizing size, low power consumption, low weight and comfort wearing compared to the means. (Bazzarelli, 2003) All of this, including low weight, its non-visibility while using, low power consumption and the method of its application is easy. The device is a small necklace with very low battery consumption and the user does not feel the weight on the neck. The method of its application is easy and it doesn't need a specialist or x-rays and the information it provides is beneficial and can be useful for the user and the therapist.

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