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Measuring the Negative Impact of Long Sitting Hours at High School Students Using the Microsoft Kinect

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Abstract. This paper suggests the usage of the Microsoft Kinect to detect the onset of the scoliosis at high school students due to incorrect sitting positions. The measurement is done by measuring the overall posture in orthostatic position using the Microsoft Kinect. During the measuring process several key points of the human body are tracked like the hips and shoulders to form the postural data. The test was done on 30 high school students who spend 6 to 7 hours per day in the school benches. The postural data is statistically processed by IBM Watson's Analytics. From the statistical analysis we have obtained that a prolonged sitting position at such young ages affects in a negative way the spinal cord and facilitates the appearance of malicious postures like scoliosis and lordosis.

Keywords. spinal cord, scoliosis, students, orthostatic position, seated position

1. Introduction

Seated position is a less strenuous than orthostatic position for several reasons: area of support is higher faces being represented by the thighs and rear faces of the lower limbs planting on the ground; the center of gravity of the body is closer to the supporting surface or base support and is designed to the posterior body part; energy request is lower; cardiovascular activity is easier; muscular effort to maintain stability and balance of the body is less..

If prolonged work in a sitting position is performed disorders of the muscles, tendons, neck, shoulders, stress, side effects that may even lead to mental or psychiatric disorders [1] may occur. Extended use of the computer has some-times vision disorders as effect.

It is recommended for people working in an office environment to have a neutral posture of the body as depicted in Figure 1. The neutral posture of the body in a sitting position is with the shoulders in a relaxed position, the back part of the body in a vertical position and well supported by the backrest. The forearms need to be parallel with the floor and the elbows close to the body as shown in Figure 1, left. [2].

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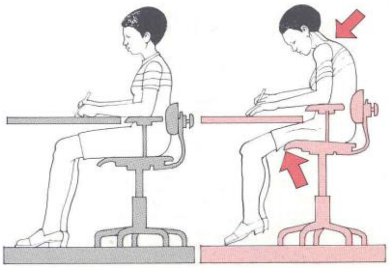

Figure 1 Left: Recommended body work positions, Right: incorrect body work position

Working in an office is often seen as having a low risk, but there are actually a number of risks to which workers in an office environment are exposed:

- Postural problems: due to sedentary work, static posture and prolonged work in forced position due to improper arrangement of the work station;
- The duration, intensity and design office work: working for long periods of time on computer keypad, no keypad de-vices and computers, with frequent and repetitive movements of the hand / wrist, with high levels of concentration and over loading information.
- Psychological facts (subjective perception of workers on work organization): it works with the perception that work is demanding, often under time pressure, low self-control over working hours, inadequate support from managers and colleagues;
- Environment: work at inappropriate temperatures, inadequate lighting, noise, restricted access and obstructions. For example, office floor design can create difficulties in terms of communication and concentration for office workers

The basic rules to create an efficient working and studying are for high school students are presented in Figure 2 [3].

2. Methods

In Romania high school students often spend 6 to 7 hours of a day in a poorly designed bench in the class rooms. They only have a 10 minute break between courses at 50 minute intervals. After school hours generally the students spend 2-4 hours to prepare for the

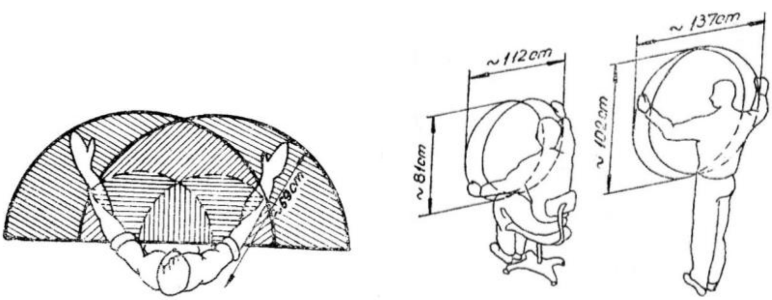

Figure 2 Horizontally maximum working area and Maximum vertical zone to special works conditions: Left. Sedentary position ; Right . orthostatic position

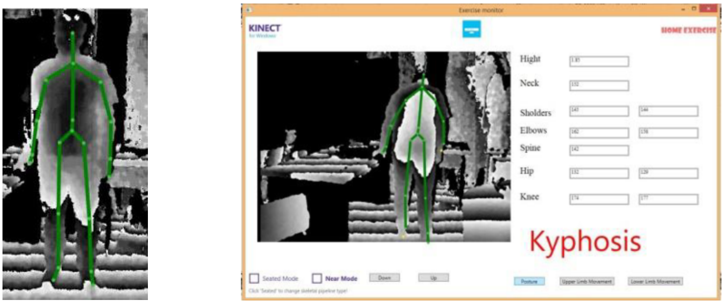

Figure 3. Left: Kinect skeleton data representation, Right: posture measuring tool

next day. In these conditions which facilitate the prolonged relaxation of several muscles from the upper body they have the risk of developing some kind of malicious body postures. The most common malicious posture malformations are the kyphotic and scoliotic body postures. With regular screening these malicious body postures can be detected in early stages and corrected using medical rehabilitation exercises.

2.1. The scanning method

The proposed screening method uses a non-invasive, non-irradiant and marker less human body tracking method based on the Microsoft Kinect 3D sensor. This sensor has already proven it's usability in the medical rehabilitation domain with several medical applications [4]. It is capable to detect the human body posture in orthostatic position and in a seated position [5].

The sensor uses a structured light system based on an IR grid projected from the IR (infra-red) laser diode. Using an IR camera the system detects the grid and creates a depth map of the surrounding space. The system is capable to separate the human body from the rest of the objects. The detected body is represented as a "matchstick" skeleton like in Figure 3, left:

The markerless tracking system can track 20 joints of the human body and for each joint assigns a 3 dimensional value which represents the joint position in Cartesian space. The X coordinate represents the horizontal space, the Y coordinate represents the vertical space and the Z coordinate represent the depth space.

To get a relevant view about the patient's posture several correlations between the tracked joints must be analyzed. The most important correlations are given by the angles between the interested joints. These angles are calculated using the 2 vector method on a 2 dimensional plane projection.

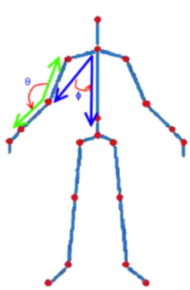

Figure 4. The 2 vector method

The method implies 3 joints on a 2 dimensional plane; the first joint called the middle joint represents the point where the angle is measured and two other adjacent joints between which the angle is measured. The formulas are presented below (Eq. 1-3):

$$A \bullet B = (Ax \bullet Bx + Ay \bullet By) \tag{1}$$

$$|A| = \sqrt{Ax \bullet Ax + Ay \bullet Ay} \tag{2}$$

$$theta = \cos^{-1}\left(\frac{A \bullet B}{|A||B|}\right) \tag{3}$$

where *A* and *B* are the adjacent joints of the joint of interest and *Ax, Ay, Bx* and *By* are the Cartesian coordinates of the A and B points. |*B*| is calculated using equation (2). *Theta* is the searched angle.

Using these angles at key points and there depth data an image of the posture can be created.

2.2. Tracked body points and measured values

The proposed screening method is a non-irradiant markerless tracking method which reduces the harmful radiation emitted from x-ray machines to zero.

The presence of scoliosis and kyphosis which affects most of the high school students [6] determines an abnormal position of several body parts like the shoulders and the hips. Using the Kinect several spatial properties of the shoulders and the hips are registered:

- Height of the left and right shoulder and the difference between the two heights.
- The angle created by the two shoulders at the neck.
- The rotation of the shoulders: if one of the shoulder is significantly deeper than the other one.
- Height of the left and right hip and the difference between the two heights.
- The angle created by the two hips at the center of the hip.
- The rotation of the hips: if one of the hip is significantly deeper than the other one.

If the patients stay completely still there is enough only one measurement to get the necessary details for the postural evaluation.

The measured data is then compared with a control digital model that was created using 5 healthy people. To create the digital control model 5 measurements were taken and there mean value was calculated.

The difference between the measured values and the values from the digital model can give us an indication if the subject is suffering from a kind of posture malformation.

The raw measurements are saved into a *.CSV file. The generated file contains on each row one measurement for each patient. The saved data for each patient are the following: unique anonymized identifier, age, sex, weight, height, BMI (body mass index), height of the shoulders and the difference between the two shoulders, the angle of the shoulders at the neck, rotation of the shoulders and the same properties for the hips. To get correct measurements the Microsoft Kinect must be set up in the following way:

- The patient must be at 2.7 meters from the sensor
- The sensor must be at 65 cm from the ground, perpendicular to the patient's hip. If the patient is taller than 2 meters the height of the sensor must be adjusted.

- The patient must not wear high heels due to negative effects on overall measurements.
- The patient must not wear loose clothing, it is recommended to wear a sports top and shorts.

The saved data from the CSV file is imported in an EXCEL compatible file and then analyzed using IBM's Watson analytics software [6]. This tool permits to visualize any kind of correlation between the measured values. The most important from our point of view was to correlate the height difference between the shoulders and the age of the patient's. This correlation has been chosen because there is a great distribution of heights between high school students at the same ages.

3. Results

The system was tested with 30 high school students (18 male; 12 female). The average age of the high school students was 16 year's old. In the first stage the students were measured with the Kinect device and after that they were consulted by a medical rehabilitation specialist.

The raw data from the evaluations were analyzed using IBM's Watson analytics software. The IBM's Watson analytics software was chosen because it can visualize any kind of correlation between the measured values.

One of the measured key metrics was the difference between the heights of the shoulders in correlation with the patients ages. A second reason to choose this value was that the high school students spend 6 to 7 hours a day in a poorly designed desk in an incorrect sitting position like in Figure 1 B. From height difference of the shoulders we can infer if there is a problem with the general posture of the patient. In Figure 5 it can be observed the shoulder height difference distribution by height differences.

It can be observed that most of the students have a higher shoulder height difference value than we would expected. This can be explained with a longer period of time spent in an incorrect sitting position. The two spikes are confirmed scoliosis cases as well as the last negative spike.

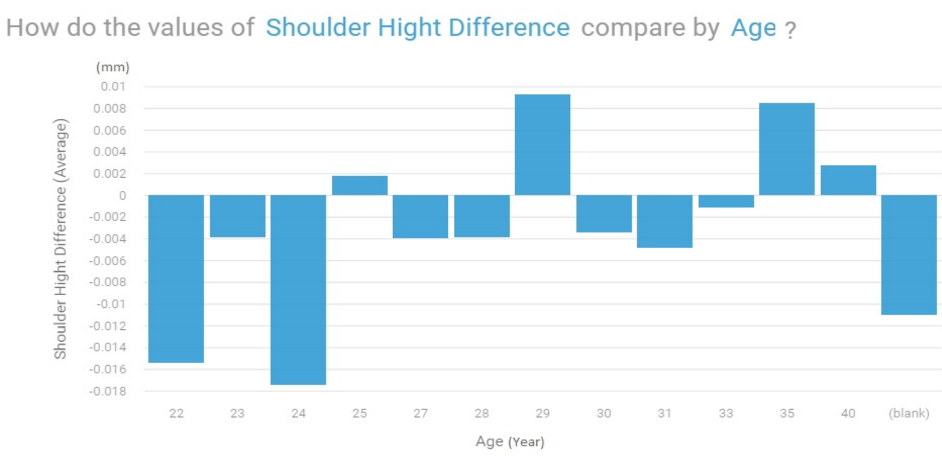

Figure 5. Shoulder height difference distribution by the age

Table 1. Systems confusion matrix

Evaluation	Kinect Scoliosis	Kinect Normal
Medic Scoliosis	17	2
Medic Normal	1	10

After the Kinect evaluation each patient was evaluated by a medical doctor to confirm or infirm the scoliosis diagnosis. This evaluation was a blinded evaluation based on which the confusion matrix form table 1 was created.

The confusion matrix confirms that the Kinect device can be used in the high school education system to monitor the changes of the spinal cord to detect in early stages the signs of scoliosis and kyphosis.

4. Discussion

The study revealed that the high school student's musculoskeletal apparatus is affected by the prolonged sitting positions. The results confirm that the prolonged sitting positions at young ages have a negative impact on the spinal cord. If not prevented or treated the malicious postures induced by the long sitting hours can affect the student's spinal cord. The diseases of the spinal cord will be visible after the age of 30 years.

The Microsoft Kinect is easily implementable at any high school or elementary school and can be an effective preventive tool. Due to the fact that it uses non irradiant infrared laser beams it can be used at every physical activity classes.

The confusion matrix showed that the Kinect is not the most accurate screening device the KINECT-based method has advantages, as it could potentially be deployed as a cost-effective addition to conventional methods in a high school setting.

Active medical supervision is necessary for patients with existing problems in order to prevent further complication occurrence.

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