UNIVERSITY OF MEDICINE AND PHARMACY "VICTOR BABEȘ"
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Doctoral Thesis

CONTRIBUȚII LA MONITORIZAREA TRATAMENTULUI PRECOCE DE REABILITARE MEDICALĂ A DEVIAȚIILOR AXIALE VERTEBRALE LA COPIL ȘI LA ADULTUL ACTIV FOLOSIND SISTEME INFORMATICE AVANSATE, STUDIU EXPERIMENTAL ȘI CLINIC.

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The general part

1.Introduction.

The main purpose of this research is to improve the monitoring of the medical recovery process of patients with axial spinal deviations. Adults and children with this pathology are often not diagnosed correctlu in early stages. Due to the long term and non interactive treatment, the patients are reluctunt to follow the treatment. Real time evaluation is scares due to the invasive and iradiant evaluation methods(X-Ray) so the treatment can not be adjusted in real-time.

In this study, a non-invasive evaluation method is proposed by using the Microsoft Kinect sensor, which scan the patient's position, without being invasive and irradiatint. It can identify major joints of the human body using an infrared (IR) laser. Using Kinect Sensor real-time, non-invasive and non-irradiating monitoring of vertebral axial deviations is performed and an evolutionary prognosis will be given

The novelty brought by this research is the possibility to evaluate the patient both initially and during the treatment without using x-ray. Dynamic evaluations can be performed both at the doctor's request and at the patient's request. It can dynamically track the evolution of its pathology and of course the results of the work performed. At adolescents and children a visual confirmation of the results of theier work is an important motivation

Spinal axial deviations are the main cause of pain in the spine in adult life. Thus, it is very important to diagnose postural abnormalities and correct them in early stages, to reduce pain in the spine, to increase mobility and muscle tone. Schroth therapy has great results in reducing the Cobb angle in scoliosis or Scheuermann's disease.

Low back pain and chronic back pain are pathologies present from young ages to older ages, so the axial vertebral deviations put their mark on all ages. Due to the excessive digitization that has reached the level of all age groups, we find more and more kyphosis and scoliosis in children and adolescents. They use a tablet, phone or computer for a large number of hours / day, having a poor postures when using these devices. Children and adolescents spend an increased number of hours at school, often in non-ergonomic banks that are not adapted to children's heights, favoring a wrong posture. In the first instance the muscule that holds the spine contracts and the muscular pains appear, then the postural changes appear. Without specialized help, such as posture correction kinetotherapy, postural changes become permanent.

In the life of a young adult, the changes that occur in adolescence are becoming more and more painful, and the frequency of painful episodes increases with age. If muscle contracting occurs in children,it will limit the mobility and will decreas the muscle tone, later in adulthood it may develop disc hernias that cause major pain, decrease work capacity and decrease quality of life. Without proper physiokinotherapeutic treatment, disc hernias may require spine surgery.

It is very important that both children / adolescents and adults are diagnosed early and will follow a correct long-term treatment. Adherence to treatment in chronic diseases is generaly deficient, which is why we want to develop an interactive system that allows efficient monitoring and captures the attention of patients to increase the adherence to the treatment.

2. Anatomy and biomechanics of the spine

2.1 Overview

The spine is the axial support element of the trunk, it is located posteriorly and medially. It consists of 33-34 vertebrae, which are arranged metameric. Depending on the regions where they are located, they are divided into: 7 cervical vertebrae, 12 thoracic vertebrae, 5 sacral vertebrae and 4-5 coccygeal vertebrae.

2.1.1 The Spine

The spine has an average length of 73 cm in the male and 63 cm in the female, it represents about 40% of the height of a person, in figure 1 we can see a spine as a whole. At the base of the sacrum the spine reaches a maximum width of 11 cm, from where it decreases both up and down.

2.1.2 Functional importance of the spine.

The spinal cord is protected by the bone layer of the spinal canal. It is formed by the overlap of vertebral bodies and vertebral arches. In orthostatism, the spine has the static role of supporting the head, trunk and upper limbs, then transmits the weight to the lower limbs and pelvis. Increased strength of the spine is due to sagittal curves. Exaggeration of the normal curves of the spine can lead to its pathological curves. Increased posterior convexity is characteristic of kyphosis. Pathological laryngosis is defined by accentuating the anterior convexity. Scoliosis is the accentuation of the curves in the frontal plane. These pathological curves of the spine can be hereditary or acquired, they can influence the normal development and functioning of some viscera.

3. Spinal axial deviations

3.1 Scoliosis

Scoliosis is a chronic, evolving disease over time, characterized by one or more lateral curves of the spine. These curves of the spine are observable in the frontal plane, being associated with the rotation of the vertebrae. This pathology has a major impact on the morphology and functionality of the human body. Over time there are important repercussions on the whole organism. It affects between 3% and 30% of the population. The incidence of scoliosis increases with age.

Scoliosis does not have a well-established etiology. In the last studies, a special role of genetics is identified, thus it is assumed that the involvement of chromosomes 6,9,16,17 in the case of idiopathic scoliosis The appearance of scoliosis can be determined by the following factors: growth hormone secretion, connective tissue structure, adrenal dysfunction , thyroid dysfunction, vestibular dysfunction, melatonin secretion, a microcytic structure of platelets and a malfunction of the patient's proprioceptive mechanism.

3.2 Kyphosis

The kyphosis represents a deviation of the spine in the sagittal plane, the exaggeration of the normal curvature. In the case of kyphosis the orientation of the curvature is oriented posteriorly.

3.3 Lordosis

Lordosis is a sagittal deviation of the spine with an anterior convexity. It is found predominantly at the lumbar level where we can see a pelvis inan accentuated anteversion, it tends to have a horizontal position and the abdomen is more prominent.

The special part

4. Distribution of patients by groups

The study was conducted in the period 2015-2018 in primary and secondary schools as well as in universities . 263 patients were included in the study , divided into 3 groups (group 1: 92 patients, group 2: 75 patients, group 3: 95 patients).

Inclusion criteria for lot 1 and 3

Patients can participate in the study if they are presenting: the suspicion of a deviation of the spinal cord, a diagnosised axial deviation of the spine, a herniated disc or discopathy at any part of the spinal cord, the presence of a lumbar back pain, or the presence of any kind of pain of the spine. All patients involved in the study expressed a written consent to participate in the study. Both photo and video materials along with the results obtained during the study can only be used for scientific purposes.

Inclusion criteria for lot 2

Patients who can participate in the study: must have an age between 10 and 16, to present a suspicion for a vertebral axial deviation, to have a diagnosed vertebral axial deviation. The parents or legal guardians of all patients involved in the study have expressed their written consent to participate in the study. All materials, both still and video and with the results obtained during the study can only be used for scientific purposes.

Distribution of the study lots

The distribution of the patients participating in the study within the groups was as follows:
Lot 1: (92 patients): 29 women (32%) and 63 men (68%);
Lot 2: (75 patients): 47 women (63%) and 28 men (37%) ;
Lot 3: (95 patients): 26 women (30%) and 60 men (70%).

The percentages presented in Table 15 and figure 47 do not indicate a large difference between the number of patients in the groups. The statistical test of Table 15 is confirming the absence of a significant differenc between the groups in terms of number of patients. However the statistical test revealed a significant difference between groups of women / men distribution

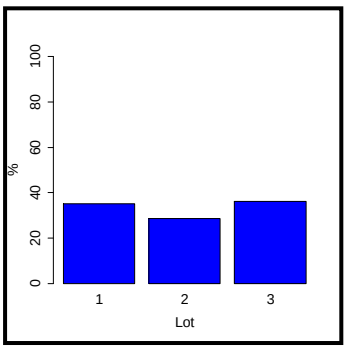

Figure 47 Distribution of the number of patients.

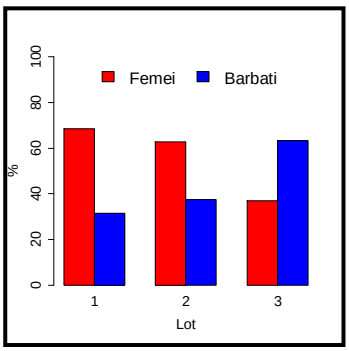

Figure 49 Distribution of women / men.

Statistical processing

The numerical data that was statistically processed represents the: age, height, BMI (body mass index), as well as the absolute differences between shoulder heights, shoulder depths, hip heights and hip depths.

Descriptive statistics of the numerical data included the mean, standard deviation, median, maximum value and minimum value of the presented numerical data.

Numerical data were tested for normal distribution using the Shapiro-Wilk test. The absence of the normal distribution determined the use of nonparametric tests (Wilcoxon signed rank, Wilcoxon rank sum and Kruskal-Wallis) and the Spearman correlation coefficient.

The qualitative data were represented by the group of the subject and the distribution of men / women.

Statistical data of qualitative type was made using the test χ^2.

The corresponding graphs supported the data in the tables.

The level of statistical significance was set at 0.05.

The statistical programming language R was used to produce descriptive statistics, statistical tests and graphs (1).

5. Evaluation method

Non-invasive postural evaluation using Kinect Sensor

To represent a digital model of patients' orthostatic posture, we chose to evaluate patients using the Microsoft Kinect sensor. It is capable of creating a digital skeleton of the person without the need to attach markers to the human body. The Kinect system is a complementary system to the existing and known ones [54], which are radiant and expensive medical equipment. The proposed Kinect system for scanning the patient’s postures is a non-invasive, non-irradiating optical system that can identify major joints of the human body using an infrared (IR) laser (Figure 50).

The sensor uses a structured light system based on an IR grid designed using an IR laser (infrared) diode. Using an IR camera, the system detects the grid and creates a depth map of the surrounding space and the scanned human body. The system is capable of separating the human body from the rest of the objects.

The human body detected and represented by the Kinect system.

6. Treatment

Treatment objectives

The goals of treatment differ depending on the group of patients. Thus for group 2 we have the following objectives: to increase the muscle tone, to decrease the paravertebral muscle contractions, to decrease the Cobb angle, to improve the orthostatic posture, to decrease the asimetri of the shoulders and hips, maintaining and increasing the mobilized respiratory volumes, to increase the stamina and to decrease or to maintin the Body Mass Index.

The goals of treatmen for group 1 and 3 are: the decrease of the lower back pain, to increase the mobility of the spine, the relaxation of the cervical, dorsal and lumbar muscles, to improve muscle tone, the improvement of the quality of life by improving the ADL, to increase the stamina and to decrease or to maintin the Body Mass Index and to increase the movement amplitudes.

7 Results, Dicutions and Conclusions

The presented results show that the proposed system based on the Microsoft Kinect is a performant screening and monitoring system. It can be used to monitor the intermidiate and final outcomes of the patients how are undorgoing the medical rehabilitation treatment for scoliosis and kyphosys.

The results reflect a well-defined study consisting of 263 patients. They were assigned to three different groups: a group made up of young adults, a group made up of children and a batch of adults. The first group of patients consisted of 92 pacinenţi of which 63 participants female and 29 male participants. The second group consisted of 75 patients of which 47 participants female and 28 male patients. The third group consisted of 95 patients of which 35 participants female and 60 male participants.

After the first measurement it was checked whether the incidence of scoliosis is correlated in some way with the patient's BMI. The statistical results presented no statistical correlation between BMI and the incidence of scoliosis for any of the three groups. Thus we can say that the occurrence of scoliosis is not related to the evaluated persons BMI.

The statistical results showed that vertebral axial deviations addressed in this paper are not influenced by the patient's height, so we can say that there is no actual link between height and vertebral axial deviation of the patient in any of the groups studied.

At the first assement the incidence of asymetry in the vertical axis of the shoulders showed that group 3 (composed of adults) has a lower mean value than the other two groups. The most affected by axial deviations are the participants of group 2 (consisting of children). This group from multiple reasons have a statistically significant asymmetry at the houlder level on the vertical axis. From the statistical point of view, the participants of group 1, with a predilection for the female participants, have presented the minor asymmetries in the vertical plane, at the shoulder level.

Statistical processing showed that there is no correlation between the patient's height and the height difference of the shoulders if the patient suffers from scoliosis. Statistical processing showed the absence of direct or indirect correlation between body mass index (BMI) and asymmetric shoulder.

After performing the first set of measurements, from a statistical point of view, no direct correlation was observed between the values of the body mass index and the values measured for the rotation of the shoulders in the sagittal plane.

After comparing the groups, the best results were given by group 2 compared to group 3, but also compared to group 1 all group 2 had the best results. The difference between lots 1 and 3 has no statistical significance

After the first evaluation the participants of group 3 presents the most asymmetries on the sagital plane. They are the most affected because at theyer workplace they have to perform rotational movements in the sagittal plane. The next group that presents an asymmetrie of the shoulders on the sagital plane is group 1. The participants of this group spend most of theyer active hours in non-ergonomic positions in inadequate chairs and benches. Those who presented the smallest asymmetry in the sagittal plane were the participants in group 2. The statistical evaluation did not confirm a corelation between rotation of the shoulders and the patients height in the groups 2 and 3. Within group 1 there was a weak statistical correlation that had a minimal statistical significance.

At the first evaluation, there was an increased incidence of asymmetry on the vertical axis of the hips at the participants of group 2. One of the main causes of this assymetry is the incorrect seated position during active hours. The participants of group 1 presented an average asymmetry of the hips on the vertical plane. The least affected by the asymmetry of the hips on the vertical plane

Statistical processing indicated the lack of a direct or indirect correlation between the body mass index (BMI) and the asymmetry of the hips in the vertical axis at all 3 measured groups. The difference between the hips height of patients in groups 2 and 3 was not correlated with the height of patients in these groups. There was no statistically significant difference between the initial values regarding the difference between the height of the hips, as in the case of the difference between the height of the shoulders.

From the statistical point of view in the first evaluation, the participants of group 3 were the most affected when it came to the incidence of asymmetry in the sagittal axis, respectively the rotation of the hips. The participants of group 1 presented an average asymmetry of the hips in the sagittal plane and the least affected by the asymmetry of the hips on the vertical plane were those in group 2.

We obtained a value close to 0 of the correlation coefficients, which objectified the absence of correlation between the depth of the hips and the height of the subjects in each of the 3 groups evaluated. After analyzing the results obtained at the first statistical measurement, no direct correlation was observed between the body mass index. (BMI) and asymmetry of the hips in the vertical axis at all 3 batches measured

The second set of measurements was performed after 6 months in which participants were tasked with performing various medical recovery exercises based on Schroth therapy.

At the second evaluation the difference between the depths of the shoulders was maintained in group 1, which shows a possible low adherence to the treatment scheme. Group 2 and Group 3 had a statistically significant improvement in values regarding the evolution of the difference between shoulder depths

After the second measurement, the following were observed:

- Group 1 it obtained good results for reducing the asymmetry of the shoulders in the vertical axis but the desired results in the sagittal axis were not obtained. Hip asymmetry in the vertical axis increased as well as asymmetry in the sagittal axis. These results can be explained by the fact that the participants did not show an increased adherence to the treatment scheme.
- Group 2 obtained excellent results: the asymmetry of the shoulders in the sagittal and vertical axis was reduced, asymmetry of the hips in both the vertical and sagittal axis was reduced.
- Group 3 it has obtained good results for reducing the asymmetry of the shoulders in the vertical axis and the results for reducing the asymmetry in the sagittal axis are significant. The results for reducing the asymmetry of the hips in the vertical axis were not as expected but neither did the asymmetry progress. Asymmetry of the hips on the sagittal axis decreased significantly.

The statistical evaluation carried out showed the existence of lower initial values of the difference between the depths of the hips compared to the initial values of the difference between the depths of the shoulders. The difference between the depths of the shoulders

decreased significantly in groups 2 and 3 but in group 1 there was no statistically significant decrease. The patients in group 2 had the best results compared to those in group 3.

The patients in group 2 and 3 presented improved values of the difference between the height of the hips, but in the case of the patients in group 1 no statistically significant improvements were detected. The subjects in group 2 had better results compared to those in group 3.