UNIVERSITY OF MEDICINE AND PHARMACY CRAIOVA

PhD SCHOOL

PhD THESIS

ABSTRACT

MATHEMATICAL MODELS REGARDING THE OCCUPATIONAL MORBIDITY BY STATIC DISORDERS OF THE SPINE

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SUMMRY

INTRODUCTION

The bone, muscle and joints system disorders represent one of the most frequently encountered entities between pathological manifestations, both in terms of morbidity, and in terms of economic expenses. The data furnished by *U.S. Health and Nutrition Examination Survey* has indicated after a study extended on a period of five years that approximatelly 47,8% of the examined adults presented a history or symptoms of some chronical bone, muscle and joints system disorders. First stood cervical spine disorders, particularly dorsal and lumbar, followed by diseases of the hip joint scapular-humeral, fingers.

In Europe, the most common work-related health problem is the disorders of the bone, muscle and joints system. A percentage of 24% of EU workers report suffering from backache and 22% muscle aches. In 2006, statistics show that in Romania musculoskeletal overuse ranks first in the hazard exposure, representing 20.48% of the number of workers exposed to hazards.

Thus a shift in the work related pathology pattern has emerged, meaning a net increase in the bone, muscle and joints system disorders, producing an alignment to other European countries where the largest number of occupational diseases is represented by the musculoskeletal and joint diseases dued to overloading at work. Thus, musculoskeletal diseases, tend to occupy the place of other occupational diseases such as dermatosis or pneumoconiosis, which is explained by significant changes in the workplace activity produced in recent decades.

The mechanization and the automation of the work processes have considerably decreased the physical effort at work in many professions, but not entirely. New technologies have implied repetitive movements, quick movements, awkward positions, positions maintained over long periods of time, or use of static positions for professional tools ergonomically unadapted, which are usually designed for the average worker, usually male. The one that conferes the body the strength and support necessary for performing these positions is the musculoskeletal system. The bones, connected by joints, serve as levers operated by the muscles. The muscles are attached to the bones by tendons. All activities that require too much stress on this system can cause musculoskeletal disorders.

Musculoskeletal disorders imply appart from the immediate physical symptoms deeper implications such as low self-esteem, impairedvquality of life, disturbance of the financial situation of the affected person. Diagnosis and early intervention can help people with musculoskeletal disorders to stay fit and maintain work. This would have a positive impact on workers with musculoskeletal disorders, and on the economy by reducing the number of sick days and increase productivity.

The production costs of musculoskeletal disorders include:

- the costs of direct prevention, detection, treatment, rehabilitation and long-term care
- the costs in indirect workload lost, lost productivity, lost earnings, lost state income tax - intangible costs due to reduced quality of life: family stress, workplace stress, economic stress and suffering.

To improve workplace conditions for employees with musculoskeletal disorders the collaboration between physicians, employers, employees and the government is needed.

Early diagnosis and rapid establishment of a treatment can reduce the severity and progress of the disease, while a delay in diagnosis or treatment can cause difficulty in recovering, rehabilitating or maintaining the employment. Managers can change the way of organizing activities to prevent worsening musculoskeletal disease and support people with these conditions to remain or to return to work, taking into account the regulations on health and safety.

The thesis is divided into two parts: the general part which contains theoretical concepts that support the importance of the chosen theme and the special part that includes: material and method, results obtained by assessing patients, discussion and conclusions.

In the first part I considered useful to insist on the notions of anatomy and physiology and the function of the musculoskeletal system of the spine and its biomechanics, as well as the risk factors involved in affecting the spine, the notions of Kinesiology and ergonomics in the workplace.

Most musculoskeletal disorders cause discomfort, local pain or limited mobility that reduce the normal performance at work and in daily activity. Almost all musculoskeletal disorders are related to work in that exercise can aggravate or even cause symptoms if the disorder is not directly caused by work. In most cases it is not possible evidence of a specific risk factor for musculoskeletal disorders. Often there are several risk factors. For most musculoskeletal disorders, weight lifting at work or leisure is an important risk factor. Overloads, sustained effort and repetition can cause diseases in various tissues of the musculoskeletal system. On the other hand low levels of physical activity may damage muscles, tendons, ligaments, cartilage and even bone. Keeping these tissues in good condition requires an appropriate use of the musculoskeletal system.

The musculoskeletal system consists of similar tissue in different parts of the body that provides an overview of the disease. The muscles are the most frequent seige of the pain. The tissues from the lumbar spine are most commonly affected.

In the neck and upper limbs, the nerve and tendon disorders are most common, while in the lower limbs, osteoarthritis is the most common disorder.

In order to understand these differences in the body is necessary to understand the main features of the anatomy and physiology of the musculoskeletal system and to know the molecular biology of different tissues, nutrition and factors that may affect normal function. Biomechanical properties of different tissues are also fundamental. It is also necessary to understand the physiology and pathophysiology of different tissues. For many conditions there are conclusive data about risk factors at work, but for now are only limited information about the relationship between the effects of exposure to risk factors and diseases. Such data are needed to establish safety standards at work.

Keywords: professional vertebral deformity, scoliosis, back pain, risks in the workplace.

THE RESEARCH MOTIVATION

The musculoskeletal disorders represent a common cause of absenteeism from work at considerable cost to the health system. Research is focused on identifying risk factors in the workplace to reduce their productivity growth.

THE RESEARCH GOAL

The purpose of this thessis is to establish:

- If there is a causal link between profession and spine deformities;
- What are the risk factors involved;
- Which is the mathematical pattern profession-risk factors and spine deformation;
- Creating a sofware to predict the likelihood of a subject of developing vertebral deformities using this mathematical model.

The difficulty resided in the fact that our studied group was very small compared with the large number of stratification by profession and the types of deformities.

MATERIAL AND METHOD

There were 189 patients enrolled in the study, admitted between 2012-2013, chosen arbitrarily, without a control group, all of them had spine deformities and were active professionaly. We could not determine neighter the chronological age of the spine strain nor the time of it`s occurrence. Most subjects were examined with the occasion of the annual check up by the occupational physician. In this study we looked for possible links between the profession and the magnitude of spine deformation. Thus, the following parameters were monitored:

- individual data (gender, age, origin, height, weight, body mass index, profession, occupation period, length of employment, addictions, sports, education level, family history);

- the activity at work (number of hours standing, the number of hours sitting down, kind of movements, lift / weight bearing, vibration and microclimate in the workplace);

- clinical examination (VAS score, Roland-Morris questionnaire, the type of spine deformation, spinal segmental mobility, muscle testing, muscle contracture when examining symptoms);

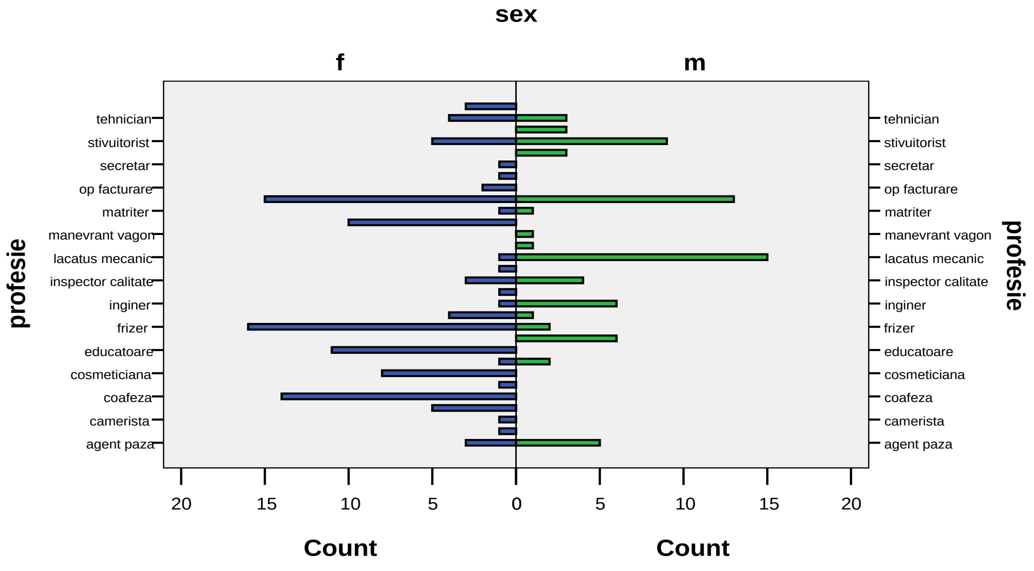
- We have noted also the associated pathology, treatments performed and the number of days of sick leave for spinal disorders.

We have statistically processed the data and watched if there is a pattern of the static spine disorders in subjects according to their professions. The statistical tests we used were: Pearson correlation test, chi square test (X2), OR and RR indicators, regressions, Student test and ANOVA.

RESULTS AND DISCUSSIONS

In the bimodal analysis of the studied parameters we have notied:

- The gender influences the preferential choice of profession. Coarsely, this is shown in absolute figures in Chart 2, in which professions like barber, hairdresser, teacher, beautician, operator billing are more predominant for females (left) versus professions more frequently encountered in males (right) like - locksmith, moulder, forklift operator.



Graph 1. Distribution of the profession and gender groups

From the statistic point of view the causal link between occupation and gender is confirmed - Phi correlation coefficient of 0.732 (p <0.001) 0.732 V Cramer`s highly significant (p <0.001) and contingency coefficient 0.59 (p <0.001)

- Women were more characteristic of being a barber and men being a locksmith. The estimated risk is 0.836 ± 0.027, the importance of sex to determine a model for choosing a profession is 0.028.

- The addressability was higher for workers in urban areas.

- There is a correlation between subject's age and type of profession (1296.97 Chi square, p <0.001; Phi 2.6; Cramer`s V 0.486; Contingency coefficient 0.934 - p <0.001). Mainely, hairdressers and several other categories of trades "classic" are more common in subjects with a longer working period.

- There is a weak correlation between the type of profession and vices subjects - 143.206 Chi square, p = 0.44; Phi 0.87, 0.43 Cramer`s V, contingency coefficient of 0.67 - p = 0.44. Operators have the No. 1 band for most vices and vices of alcohol is preferred.

- 60% of subjects had high school as the ultimate level of education, with ~ 20% vocational school with 8 classes - just 1.5% and 17.46% with higher education (Chart 12).

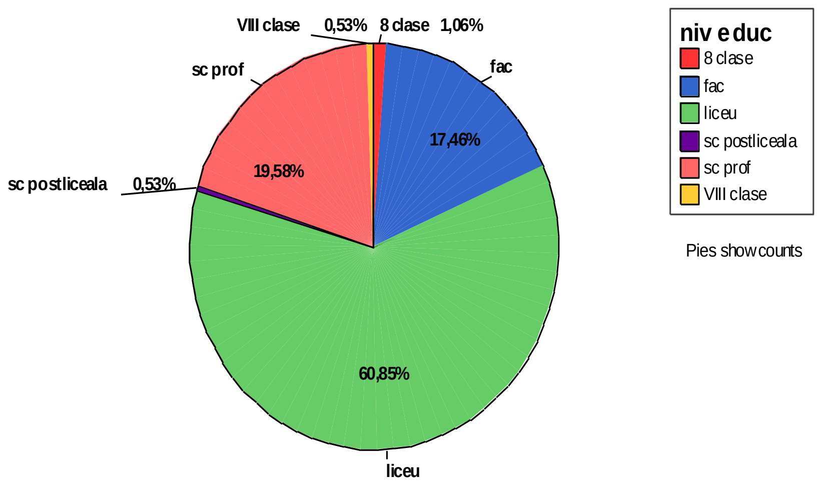


Chart 12. Level of education of the studied subjects

As expected, there ia a correlation between educational level and type of profession - 346.04 chi square p <0.001, 1.35 Phi, Cramer`s 0.605 V, Contingency coefficient 0.804 - p <0.001.

- There is a correlation between the profession and the number of hours spent in orthostatic position at work (Phi 1939; Cramer`s V 0.64; contingency coefficient 0.889 - p <0.0001). A ranking of occupations according to the request standing - standing under 5:00 - manicurists, forklift operators and educators; over 5 hours standing - hairdressers, barbers, mechanics and locksmiths, tape operators.

The influence of orthostatism at the workplace over the type of spine deformation, is void in statistical terms. We were not able to assess the dynamic impact in time, but in the studied subjects there was no causal link between the number of hours spent standing and type of the spine deformation (Chi square for each segment type of deviation column - number of hours was not statistically significant).

- There is a correlation between the profession and the number of hours spent in a sitting position at work (Chi square 588.48; p <0.001). Professions that prevailed seated over 5 hours, were manicurists and forklift operators. The number of hours in a sitting position, does not correlate with spinal deformities (chi square p> 0.05).

- There is a correlation between the profession of subjects and the types of movements at work - Chi square 227.45; p <0.001 - and, of course, it dictates the type of movement (dependent) type of correlation profession -coeficienţii Lambda hypothesis "motion-dependent professional" - 0.476, p <0.001; and Goodman same situation - 0.474, p <0.001.

But we have not found a causal relationship between the nature of movements and the deformation of the spine.

- There is a correlation between the profession and heavy lifting at work - 392.41 Chi square, p <0.001. Variable "lifting weights" is dependent on the type of profession - Lambda 0.2; Goodman 0.373; p <0.05.

The only group of subjects in which we found a correlation between the change in the sagittal plane of the lumbar segment curvature and heavy lifting at work, was the locksmiths group - 11.92 Chi square, p = 0.018 and Likelihood Ratio 13.84, p = 0.08. The correlation coefficients indicate a strong causal relationship to this category of workers: Phi 0.86, p = 0.018; Cramer`s V 0.86, p = 0.018; Contingency coefficient 0.65, p = 0.018 - all three are significant correlation coefficients greater than 0.5. Moreover, the coefficients for assessing errors shows that the distortion is highly dependent lumbar lordosis and directly proportional relationship, the request by lifting weights to work for sub locksmiths: Lambda coefficient for deformation lordosis is dependent upon heavy lifting - 0.80, p = 0.021 - confirmed, and vice versa - lifting weights dependent deformation of lumbar lordosis - 0.12, p = 0.56 - refuted. Similar results coefficients and uncertainty Tau - Tau dependence lumbar lordosis deformation under the influence weights - 0.74, p = 0.025, and the coefficient of uncertainty for the same hypothesis - 0.69, p = 0.08. In the reverse situation, the coefficients were low and beyond the materiality (see Chart 38).

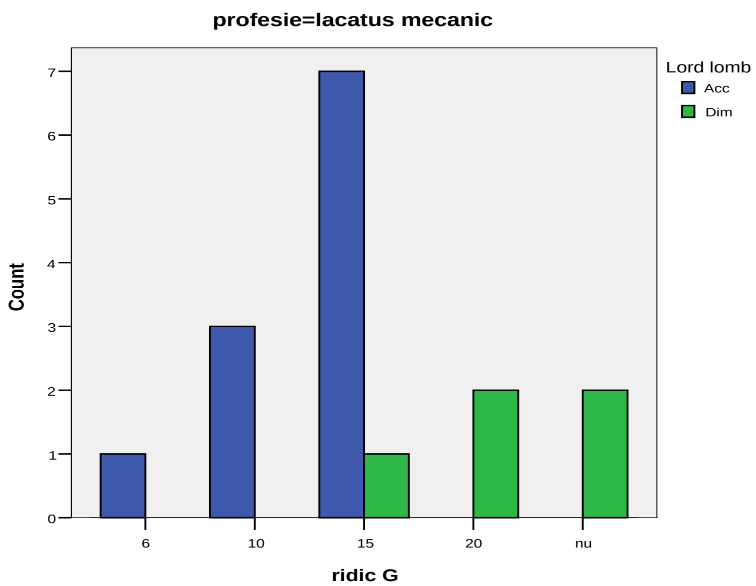
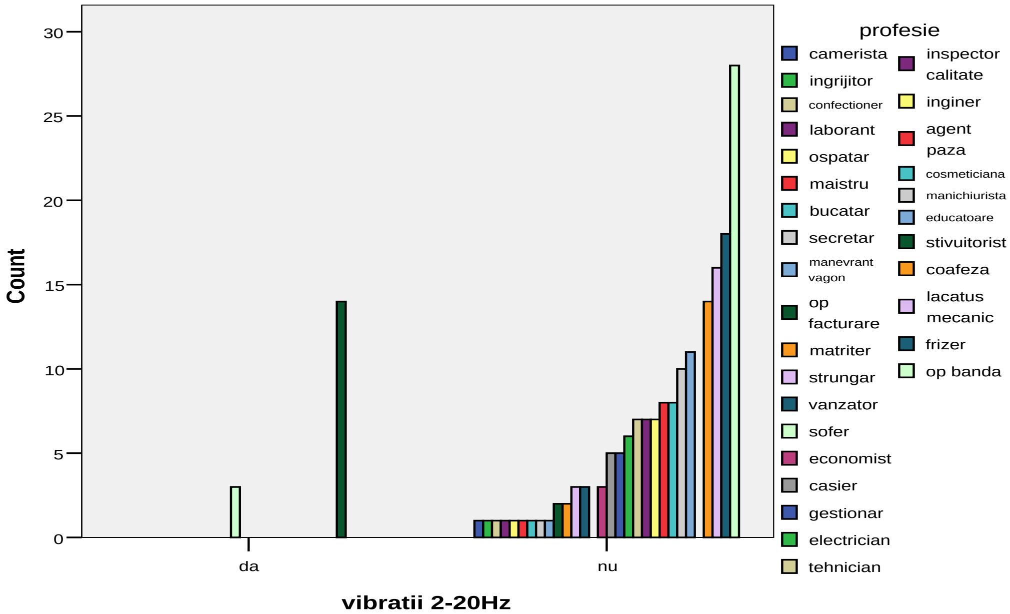


Chart 38. The frequency, the type and the distribution of sagittal plane deformities in lumbar segment under the action of high weights at work, for the first group locksmiths. There is a tendency to increased lordosis for handeling weights lesser than 15Kg and tend to decrease lordosis for handeling weights higher than 15Kg.

- There is a causal relationship generally between profession and work hands at work: 130.43 Chi square, $p < 0.001$. For managers, significant correlations were found for deformities of the cervical spine in the sagittal plane: 5,0 Chi square, $p = 0.025$, Phi and V Cramer`s 1.00, $p = 0.025$. The impact on the cervical spine is to reduce the physiological lordosis. Regarding the lumbar spine, significant correlations were found only in the band operators group (9.5 Chi square, $p = 0.008$). Dextroscoliosis had the highest incidence.

- There is a correlation between the type of profession and vibration in the workplace (189 Chi square, $p < 0.001$). Among the professions, drivers and forklift operators are exposed to low frequency vibration.



Graphic 45. The professions in which subjects were exposed to low-frequency vibrations during working hours

Although there is a correlation between the profession of the subjects and the exposure to low-frequency vibration, no correlation has been found between the exposure to low frequency vibrations and the spine deformations. Even we took into account the stratification by profession, we have not found a causal relationship, even in the most exposed professions (forklift operators and drivers).

- The working environment and the occupation are strongly correlated (536.26 Chi square, $p < 0.001$), but we have not found correlations between the changes in certain segments of the spine and the environment in the workplace. There is a weak correlation between environmental conditions in the workplace and lumbar curvature deformity in the sagittal plane (Chi square 21.52, p = 0.043). These distortions are not linked to a particular type of profession.

- Among the associated diseases took into account, only obesity is associated with the increase of the lumbar curvature (21 Chi square, p = 0.033) and affects subjects, regardless of profession.

- One can easily observe the highest frequency of consumption of NSAIDs among the tape operators, but far more significant is that regardless of profession, the NSAIDs prescription is constant for subjects experiencing increased lumbar lordosis. Moreover, this assumption is demonstrated by Lambda coefficient, which is significant in the direction of dependence of NSAIDs lumbar lordosis (p = 0.039), and insignificant when testing the hypothesis addiction profession NSAIDs (p = 0.096).

Objective assessment of static subjects with spinal disorders, was conducted by clinical examination of the spine. They used indicators of mobility, pain scores (VAS Roland-Morris), muscle testing site. These indicators change when the amplitude of movements is reduced to the respective segment. Limitation of motion may be due to acute or chronic inflammatory processes local reflex due to pain or deformation in the case of the column. Unfortunately, there was only established normal values, without specifying whether or not their changes are specific to a given pathologic spectrum

We have checked the following hypotheses :

1. The indicators for mioartrokinetic mobility are correlated or not with the changes in the spine curvatures.

2. Wheather the changes in spinal curvature correlates with altered muscle testing site.

3. If VAS and Roland Morris scores are correlated with vertebral statics disorders.

For the cervical segment the following indicators were measured: IMS, IMA, ITA and occiput-wall distance. With the aid of the chi square test was sought if any causal relationship between static spinal disorders in the neck (cervical curvature increase and decrease), and impaired mobility segment, expressed by abnormal mobility indicators.

There is a correlation between the index and occiput-wall deformities of the cervical curvature - Chi-test 16.2; p = 0.039.

To determine the cut-off value for wall-occiput distance prediction is for maximum accuracy deformation cervical segment, we proceeded to the ROC curve analysis. The coordinates of the cut-off, are appropriate sensitivity value 0.53 in the Y and X axis inverse specificity = 0.47. From the table with the coordinates of the curve, the occiput- wall indicator value can be determined, and one can observe that it is between 0 and 0.5 cm.

Thus, predictive for the increases of the cervical curve, the wall occiput- index must be greater than zero centimeters, and the sensitivity of the test is 53% with a specificity of 53%. Unfortunately, as the indicator values rise, the sensitivity increases and the specificity of the test decreases (ie - for a value of 1.5cm, will be 93% sensitivity and specificity of only 0.32%).

The Ott index was used to assess the mobility of the dorsal segment. This is done by flexing the trunk having as benchmarks, the spinous process of the vertebra C7 and 30 cm distally. Following flexion the distance between landmarks must increase by at least 4 cm. Ott index may be modified by a number of factors, but possible also by static disorders. To discern whether static disorders are responsable for the modification of the Ott index, we proceeded to Chi-square test for evidence of correlation between these two factors. In the event that there is correlation was sought to determine the minimum value of the Index Ott predictive for deformations of the dorsal segment, using ROC curves. It was found that there is a causal relationship between index values Ott and type of back strain.

Two indicators were used to assess the mobility of the spine in the lumbar segment: Schober index and finger-ground index (IDS).

The Schober index modification is not correlated with the lumbar lordosis: chi squared 25.46; p = 0.113. Schober is no correlation between index values and appearance of lumbar curvature in the frontal plane: Chi-square 44.4; p = 0.001. Although Chi-square test indicated a significant correlation between the two factors (index Schober - column layout in the frontal plane), it does not specify which group of subjects correlate with Schober index (scoliosis or normal).

An alternative method to the Student Test are the ROC curves, with which we can determine the value of the index Schober cut-off to classify the subjects. In all three cases (normal aspect of lumbar segment deviation in frontal or right / left), the benchmark was the same (15cm). ROC curve sets the benchmark for a positive test, the benchmark index of 15 cm Schober in subjects with levoscoliosis and 16 cm in subjects with dextroscoliosis. Only this is consistent with general pathology (Schober index less than 15 cm is suggestive to limit the flexion of the lumbar spine). So although Schober values are significant, they are not specific and lose their clinical importance for discriminating between other pathologies and lumbar scoliosis due to flexion limit.

Normally, the trunk flexion with straight knees, is sufficient to allow the fingertips of the hands touching the ground (the finger -ground distance index - IDS). IDS tests the lumbar segment mobility especially, the ability of flexion. It measures the distance between the index and soil at the three categories of subjects: with physiologic lordosis, with increased lordosis and with diminished lordosis. Hypothesis test - whether there is a causal relationship between the indicator values and type of static disorder, and if these phenomena are linked, what is the predictive index-ground type of deformation.

The correlation coefficient Pearson Chi-square, was insignificant association "distance index-ground" - look lumbar curvature in the sagittal plane (normal / enhanced or diminished): 14.41; p = 0.275 and remained insignificant and after correction Likelihood-ratio: 15.21; p = 0.23.

Another objective of the clinical examination, tested along twith he spine mobility, is the muscle strength test. This is done free or for a resistance that opposes muscular movements ordered and developed for test execution, the quality is assessed on a scale from 0-5 (see Table 36).

The F Scale	***The corresponding parameters of the muscle strength amplitude developedin test.***
F5	Normal muscle strength .
F4	The subject develops the force required to move the tested segment against an average resistance.
F3	The developed force moves the tested segment against gravity, without further external resistance.
F2	Segment mobilisation achieved only after canceling gravity .
F1	Muscle contraction without realizing the mobiliation of the the tested segment.
F0	Absent muscle contraction.

Table 1. The assessment scale of muscular testing on clinical examination

A brief analysis has shown that the minimum testing was obtained F2 and F4 was above average, closer to F5, which decreases the chances that static spinal disorders to be associated with alteration and muscle strength.

In multivariable analysis, we followed the deciphering of a mathematical model thatt predicts the kinds of deformation, with the variables studied parameters. For this, we used the multinomial statistical test of logistic regression because it has several advantages over other tests: it can be used for prediction, especially when the dependent variable (eg - thoracic kyphosis) is dichotomous (kyphosis can be increased or decreased to normal) and in addition, can be estimated share ratio (OR) for each subpopulation of the independent variables (ie - the variable 'subjects' profession' has 28 subgroups - barbers, electricians, etc.). Thus, it can be quantified for each type of variable magnitude, and the rate of amplification of OR can be used as the severity score. Finally, SPSS (Statistical analysis software package) returns a template built on the predictive value of the risk factors.

Thus, we can find out the contribution of each predictive factor knowing the accuracy of the final template and the maximum vaue of the risk factors sum. For example, the maximum predictive value for the mathematical model that predicts cervical curvature accentuation is 62.1% and the maximum value obtained by the sum of the highest values of exponential (Exp (B)) obtained risk factors is 1, 9E + 13. We can therefore deduce, by what percentage increase the risk of a given variable, the value is known exp (B) - example - aged 59, it has exp (B) 2.94 + 11. We report this amount at maximum Σexp (B) and precision template and get: [(2.94 + 11) * 62.1%] / 1,9E + 13 = 0.96%. So the age of 59 years increases the probability of deformity cervical segment by emphasizing the crown at nearly 1%.

The method has the advantage of establishing precisely, for each risk factor, the proportion of participating, especially when the group is not homogeneous (a group of factors, only a few can be important, and they are not proportional between them) . Another advantage is that the model is used for achieving exponential Likelihood values, leading to cancellation of negative.

So each individual factor can increase the percentage of probability to the value exp (B) the sum of their Exponentials with the highest values of the factors with which they interact. Expression values will be in scientific format (example number 100, has the expression 1 * 102 and will be abbreviated as 1E + 2).

Since working with large numbers is difficult, it requires the use of a computer program, for ease of calculation.

Cervical lordosis mathematical model

To emphasize the cervical curvature, the maximum score you can get on a subject, is 1.91 + 13, consisting of the sum of the maximum values of exp (B) of each risk factor studied. The average value is 6.38 + 10 and the total number of variables were taken into account is 614. The power of prediction is 62.1% of cases.

To decrease cervical curvature: 614 variables were analyzed, the maximum score 1.83 + 13 + 10 8.93 average, and maximum predictive power - 50.9%.

Predictive mathematical model for increasing the cervical bend:

Age [27;59;60years](0,6-1,17%)+height [152;157;159cm](3,29-5,15%)+ family history[Mother osteoporosis](7%) + Number_hours_seated[8h](6%) + Environment_work[cold+stream of air](6,5%) + Comorbidities[obesity+osteoporosis; SDAc+d+l+osteoporosis; SDAl+ lower limb static disorders](5-8%)+Treatments_performed[gymnastics/NSAIDs](3%)+Age_occupation[11;13;34;35; 44](6,5-7,5%)+ Morris[2](3)+symptoms [crackles+dizziness](3,7%)+Contracture_paravertebral[C](3%) + I. Ott[30](6%)

SDA=spondilodiscarthrosis,c=cervical, d=dorsal, l=lumbar

Predictors weak: H[153;154](1%); Hours_standing [4h](0,9%)

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= **62,1%** chance to emphasize the cervical curvature

Predictive mathematical model for reducing cervical curvature:

H[152;154;157cm](2,57-3,29)+family history[Mother with: discopathy;gonarthrosis;HD; Mother and father with lumbar disc herniation; father with HD](~7%) Hours_standing[5-8h](~9%) Hours_seated[8h](7%)+Age_occupation[34](5%)+Morris[6;10;13;17](3-

5%)+Symptoms [crackles+ dizziness; crackles+ dizziness +asthenia; inability to concentrate+crackles](3-9,8%) + i.Ott[30](2,7%)

Predictors weak: family history[Mother with osteoporosis](1,9%); Hours_standing[1-4h](<2,28%); Comorbidities[SDAc,l,d+Obesity](0,3-0,5%); score_Morris[3;4](0,03-0,07%); I_Schober[12](0,27%)

= **50,9%** predictive power to reduce cervical curvature.

Predictive mathematical modeling to segment dorsal deformities

Exponentials Likelihood Average values for dorsal kyphosis emphasis was 7.66 + 13 and the amount peaks was 3.00 + 14. Maximum power prediction template: 64.5%.

In the case of decreased dorsal kyphosis, the average of exp values (B) was 5.47 + 13 and the sum of the maximum values, was 1.14 + 16. Maximum power template prediction: 52.7%.

For subjects with dextroscoliosis the average exp (B) was 3.96 + 13 and the maximum amount was 5.87 + 15. Maximum power template prediction: 34.2%.

For subjects with levoscoliosis the average exp (B) was 1.95 + 13, and the sum of the maximum values of exp (B) 2.34 + 15. Maximum power template prediction: 36.9%.

So, the value of exp (B) of each variable will be reported to the sum of the maximum power and maximum exp prediction of each template to determine the predictive value of the variable individual concerned. Thus, the same variable (eg age 54, will have a different predictive power for each type of deformation part).

Predictive mathematical models for deformation segment dorsal

Emphasizing dorsal kyphosis:

Gender[female](1,9%)+weight[71;75;78;84;88;92;93](2,2-4,38%) +BMI[36,5(3,84%)] +education level[high school (3%); Post secondary school(3,97%); vocational school(3,58%)] +pathological personal history[SDA lumbar+Herniated disc+ lower limb static disorders (12,75%)] +sick leave [4days(2,27%); 5days(2,75%); 10days(2,9%); 12days(3,37%); 14days(3,67%)]+Treatments[gymnastics(3,97%)+Wall occiput distance

2cm(3,2%); 5cm(12,66%)]+lumbar spine extension[3(3,76%)]+lumbar spine flexion [2(7,25%); 3(10,19%); 4(12,45%); 5(12,88%)]

Predictors weak*:* age[55years](0,03%)+environment _provenance[from country](0,01%) +Height[152cm(0,01%); 186(0,01%)] +weight[50kg(0,8%); 82kg(0,15%); 55Kg(0,38)] +Education[Faculty(0,02%)] +sick leave [2days(0,16%)].

= **64,5%** *probability for emphasize dorsal kyphosis.*

Diminishing dorsal kyphosis:

Weight[84Kg; 86Kg; 87Kg; 88kg; 92kg; 96kg; 97kg; 103kg; 108kg](3,67-3,98%) +Professsion[quality inspector(8,29%);locksmiths (6,46%);driver (7,79%)] + pathological personal history [SDA lumbar+HDL+ Lower limb static disorders (14,66%); SDA cervical+lumbar+dorsal+obesity (13,93%)] + Diminished Lumbar Lordosis (6%) + ITA[3cm(9,99%); 4cm(11,73%); 5cm(11,91%); 7cm(12,37%)]

Predictors weak: age[51years(0,01%)]; Height[152cm(0,4%)];Weight [71kg(0,68%); 75kg(0,95%); 47kg(0,4%); 49kg(0,5%); 68kg(0,22%); 75kg(0,95%); 61kg(0,24%); 89kg(0,22%)]; Education[8classes(0,66%); Faculty(0,08%); High school (0,05%)]; Number of days of sick leave [14days(0,56%); 15days(0,6%)]; VAS [4(1,91%)]; Pronounced Lumbar Lordosis(1,83%)

= **52,68%** *probability to decrease the curvature of the dorsal.*

Dextroscoliosis:

Age[43years(4,2%)]+Weight[68kg(4,15;106kg(1,35%)]+BMI[24,22(5,58%); 24,97(4,07%); 25,25(4,14%); 26,53(2,31%); 26,98(4,14%); 27,46(3,31%); 27,51(4,09%); 28,13(4,18%); 28,25(4,18%); 28,57(2,31%); 28,67(4,18%); 28,57(2,31%); 28,67(4,18%); 28,72(3,61%); 30,04(1,68%); 31,02(3,61%); 31,23(4,14%); 31,24(4,07%); 32,9(3,61%)] + profession[administrator(2,7%)] + Education [Post secondary school (3,48%)] + Environment_work [cold+moisture+stream of air (2,55%)] + pathological personal history [SDA lumbar+ lower limb static disorders (4,7%); SDA lumbar(5,6%); SDA cervical(5,6%); SDA cervical+HDC (5,6%); SDA dorsal+Obesity(5,6%)] +Morris [6p(2%)]

Predictor weak: age[26years(0,01%); 36years(0,12%); 37years(0,29%); 42years(0,38%); 49years(0,07%); 52years(0,16%); 61years(0,06%); 60years(0,65%); 54years(1,6%); 58years(1%)]; Height[174cm(0,23%); 186cm(0,3%); 98cm(0,67%); 99cm(0,67%)]; BMI[24,75(0,21%); 25,39(0,86%); 25,55(0,86%); 26,2(0,21%); 26,81(0,83%); 26,82(0,21%); 27,34(0,57%); 27,54(0,57%); 27,68(1,11%); 28,03(0,21%); 28,19(0,21%); 29,29(0,57%); 29,91(1,6%); 30,09(0,16%); 30,73(0,57%); 30,93(1,17%); 31,25(0,86%); 31,79(0,21%); 31,9(0,21%); 32(0,21%); 34,15(0,86%); 34,2(0,61%); 36,3(0,68%)]; Profession[Governess(0,83%);Quality Inspector (0,34%); Operator band(0,48%)]; Weight lifting [25kg(1,24%); 30kg(1,45%)]; Morris[1p(0,05%)]; VAS[9p(1,24%)]; Lumbar spine rotation[4p(0,47%)].

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= **34,2%** *probability.*

Levoscoliosis:

Weight[90kg(2,4%); 91kg(1,74%); 94kg(2,92%); 96kg(1,79%); 97kg(2,45%); 98kg(2%); 99kg(2,03%) 100kg(3%); 103kg(2,7%); 105kg(4,8%); 106kg(2,5%)] +BMC[24,22(2,37%); 24,97(2,81%); 25,39(3,56%); 25,55(3,56%); 25,6(3,34%); 26,5(6,95%); 26,53(4,49%); 26,81(4%); 27,34(7,72%); 27,47(4,63%); 27,54(7,72%); 27,68(3,12%); 28,57(4,49%); 29,29(7,72%); 29,38(4,63%); 30,73(4,63%); 30,75(4,63%); 31,24(7,52%); 34,15(3,56%); 34,16(3,34%); 36,2(3,47%); 36,3(3,75%)] +Hours_standing[7hours(2,46%); 8h(2,64%)] +Environment_work [cold+moisture+stream of air (2,21%)] + pathological personal history [SDA lumbar+HDL+ lower limb static disorders (4,8%); SDA cervical+lumbar+obesity in history(2,39%); SDA cervical+lumbar+Osteoporosis(2,61%)] +Lumbar Spine Flexion[3p(6%)] + Lumbar spine rotation[4p(4,9%)]

Predictors weak: Weight[84kg(0,3%); 65kg(0,89%); 49kg(0,06%); 51kg(0,15%); 53kg(1%); 54kg(1%); 55kg(1%); 56kg(0,84%); 66kg(1%); 67kg(0,44%); 68kg(0,36%); 69kg(0,38%); 70kg(0,39%); 73kg(2,05%); 74kg(0,14%); 83kg(0,1%); 84kg(0,3%); 85kg(0,55%); 86kg(1,2%); 87kg(0,19%) 88kg(1,32%); 89kg(0,26%); 92kg(1%); 110kg(0,31%)]; BMI[17,55(0,86%); 21,54(0,77%); 23,3(0,33%); 23,18(0,33%); 23,38(0,33%); 23,42(0,33%); 23,43(0,75%); 23,81(0,75%); 29,06(1,76%); 31,25(0,36%)]; Profession[education(0,81%); Post secondary school (0,8%)]; Hours_standing [1h(0,35%); 2h(0,49%); 3h(0,2%); 4h(0,52%); 5h(1,3%); 6h(0,36%)]; Number of days of sick leave [14days(0,84%); 2days(0,84%); 12days(1,34%)]

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= **36,89%** *probability.*

Predictive mathematical models for the deformation of the lumbar segment

Increased lumbar lordosis:

Gender [Female(2,78%)] + Age[39years(2%); 41(4,32%); 45(1,81%); 46(1,49%); 51(2,56%); 52(10,49%); 54(5,46%); 55(5,48%)] + Height[157cm(1,09%); 159(1,14%); 160(1,17%); 162(1,36%); 163(1,4%); 164(1,5%); 165(1,56%); 166(1,85%); 167(1,7%); 168(1,79%); 169(1,73%); 170(1,86%); 171(1,74%); 172(1,8%); 174(1,82%); 178(7,89%); 180(4,13%); 181(2,51%); 182(2,36%); 185(5,03%); 186(5,54%); 187(5,18%)] + Education[8classes(5,63%); Faculty(1,44%); High school(1,43%)] + family history [Mother with discopathy(1,41%); Mother with SDAlumbar(5,78%)] + Hours_standing [7 (8,82%)] + Hours_seated [4h(1,69%)] + Carrying weights[6kg(1,3%)] + pathological personal history [obesity in history (1%); SDA cervical+dorsal+lumbar(1,75%)] + Contracture[Dorsal(1,83%); Lumbar(8,66%)] + Deformation in the other segment[Kyphosis D diminished(4,84%);Lumbar Levoscoliosis(4,79%)] + I. fingers-ground[5(2%); 10(1,99%); 15(2,21%); 20(5,65%); 30(9,03%); 40(13,09%)] + Lumbar spine extension[3(4,41%)] + Lower lumbar extension[3(6,1%)] + Lumbar spine rotation [3(3,78%); 4(9,2%); 5(9,2%)]

Predictors weak: age[27(1,12%); 28(1,81%); 29(1,75%); 31(0,89%); 32(0,39%); 33(1,86%); 36(1,46%); 38(1,67%); 40(0,19%); 42(0,88%); 47(0,56%); 48(0,15%); 49(1,26%); 50(0,28%); 57(1,42%); 59(0,27%); 60(1,34%)] + Height[152cm(0,51%); 153(0,53%); 154(0,31%); 155(0,99%); 156(1%); 158(0,42%); 175(0,36%); 176(0,27%)] + Education[vocational school((0,04%)] + family history [Mother with gonarthrosis(0,8%); Father with discopathy(0,81%); Father with HD(0,56%)] + Hours_standing [5h(0,41%)] + Hours_seated [2h(0,67%)] + Carrying weights [7kg(0,57%); 10kg(0,74%); 15kg(0,91%)] + pathological personal history [SDAc,l+obesity in history(0,57%)] + Sick leave[3;4days(0,25%); 5days(0,82%); 7days(0,59%); 10days(0,34%); 14days(1,04%); 160days(0,1%)] + Morris[6p(0,45)].

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=96,8% probability Accentuated Lumbar Lordosis

Diminished lumbar lordosis:

Age[34(3,65%); 46(1,86%); 48(2,12%); 51(3,43%); 52(3,42%); 54(3,76%); 55(3,14%); 59(2,41%); 62(2,91%)] + Height[155cm(2,99%); 156(2,28%)] + BMI [25,7kg/m^2(3,47%)] + Profession[Education(1,98%); Administrator(3,49%); Caretaker(3,49%); Locksmiths(2,24%); Operator_band(1,22%)] +

Education[8classes(3,28%); Post secondary school (1,41%); Profession(2,18%)] + Hours_standing [7h(2,89%)] + Weight lifting [15kg(1,12%); 20kg(1,93%)] + Carrying weights [15kg(1,44%); 20kg(3,39%); 30kg(1,58%)] + pathological personal history [SDAc,osteoporosis(2,99%); SDAc,d,obesity(2,99%); SDAc,d,l,osteoporosis(1,37%); SDAc,l(3,24%); SDAc,l,obesity(1,24%); SDAl,HDL(3,76%)] + Morris[3(1,27%); 6(1,12%); 14(1,47%)] + Contracture[C,D,L(2,49%); L(3,99%)] +I. Ott[32p(3,17%)] + Lumbar spine extension [3p(2,66%)] + Lumbar spine rotation [4p(1,59%).

Predictors weak: Age[23years(0,53%); 26(0,7%); 27(0,76%); 29(1,04%); 31(0,56%); 32(0,44%); 33(1,97%); 36(0,93%); 37(0,73%); 40(0,61%); 41(1,51%); 44(0,78%); 45(1,51%); 47(0,43%); 49(1,4%); 50(0,73%); 56(0,13%); 57(3,43%); 58(0,48%); 60(1,2%); 61(1,39%)] + Height[152cm(0,7%); 162(0,1%); 168(0,23%); 174(0,85%); 180(0,16%); 187(1,06%)] + BMI[25,35kg/m^2(0,35%)] + Profession[Security guard(0,1%); Cashier(0,9%); Quality Inspector (0,57%); Manicurist(0,64%); forklift operator (0,94%); Technician(1,16%)] + Education[Faculty(0,55%); High school(0,93%)] + family history [Father with discopathy(0,71%); Father with HD(0,82%)] + Age_occupation [30years(0,51%)] + Weight lifting [5kg(0,6%); 7kg(0,82%)] + Environment_work [cold (0,92%); cold+stream of air (0,73%); cold+moisture (0,74%)] + pathological personal history [HD lumbar(0,63%); Obesity+osteoporosis(0,72%); SDAc,l,HDL,obesity(0,52%); SDAc,l,osteoporosis(0,72%); SDAl,osteoporosis(0,22%)] + Sick leave[14days(0,4%); 15days(0,12%)] + Morris[7p(0,89%)] + Deformations[Kyphosis D diminished(0,78%);Lumbar Levoscoliosis(0,69%)] + Ott[33cm(0,81%) + Lumbar spine rotation [3p(0,89%)]

= ***45,5% probability to decrease lumbar lordosis.***

Lumbar Dextroscoliosis:

Age[33years(4,59%)] + Height[155cm(3,45%); 156(3,45%); 159(2,63%); 167(3,58%)] + BMI[20,59kg/m^2(2,79%); 21,9(2,79%); 23,51(2,36%); 23,92(2,36%); 25,5(1,17%); 25,59(2,98%); 25,7(3,95%); 26,19(2,79%); 26,56(2,46%); 27,46(1,17%); 28,03(2,79%); 28,19(2,79%); 29,7(2,36%); 31,79(2,79%); 31,9(2,36%); 33,5(3,39%); 35,11(2,36%)] + Profession[Hairdresser(5,39%); Beautician(3,47%); Governess (3,08%); Barber(5,52%); forklift operator (3,56%)] + Education[Post secondary school (1,91%)] + family history [Father with HD(3,93%)] + Morris[7p(1,8%);

10(5,35%); 12(5,35%)] + VAS[5p(2,31%)] + Ott[31cm(3,43%)] + Schober[12(4,88%)] + Lumbar Spine Flexion [3p(1,8%)]

Predictors weak: Age[51years(0,33%)] + BMI[20,13(0,3%); 21,22(0,36%); 21,34(0,36%); 21,51(0,36%); 21,75(0,36%); 22,4(0,36%); 22,47(0,75%); 22,53(0,75%); 23,87(0,36%); 24,7(0,36%); 24,75(0,36%); 25,14(0,36%); 25,16(0,36%); 32,00(0,36%); 33,06(0,36%); 34,16(0,47%); 26,2(0,36%); 26,44(0,36%); 26,59(0,77%); 26,82(0,36%); 27,5(0,36%); 29,37(0,36%); 29,5(0,36%); 30,09(0,56%); 30,05(0,36%)] + Profession[Locksmiths (0,42%); Technician(0,47%)] + Age_occupation [41years(0,93%)] + Treatments[Gymnastic+Physiotherapy(0,21%)] + VAS[8p(0,3%); 9p(0,66%)].

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=***44,4% prediction for Lumbar Dextroscoliosis***

Lumbar Levoscoliosis:

Weight[110kg(3,66%)] + BMI[31,9(2,68%); 34,16(2,24%); 26,5(4,02%); 26,56(1,08%); 29,7(2,68%); 30,09(1,82%); 31,23(1,9%); 35,11(2,68%)] + Profession[Beautician (2,19%); Barber(3,71%); Technician(3,86%)] + family history [Father with HD(5,3%)] + Hours_standing [6h(2,03%)] + Age_occupation [27years(1,15%)] + pathological personal history [SDAc,l,HDL,Obesity(5%)] + Morris[2(2,12%); 17(1%)] + VAS[5p(2,77%)] + Deformation[Lordosis L pronounced(2,2%); Lordosis L Diminished(1,22%)] + Schober[12cm(5,17%)] + Lumbar Spine Flexion [3(3,48%)].

Predictors weak: gender[female(0,06%)] + Age[27years(0,35%)] + Height[185cm(0,35%)] + BMI[23,42(0,13%); 23,51(0,27%)] + Profession[Hairdresser(0,79%)] + Age_occupation [12(0,1%); 16(0,15%); 23(0,21%); 26(0,13%); 32(0,21%); 41(0,15%)] + Sick leave[160days(0,17%)] + VAS[1p(0,29%)] + Deformations[Kyphosis D Pronounced(0,85%);Dorsal Levoscoliosis (0,61%)]

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= ***39,8% probability for Lumbar Levoscoliosis.***

Occupational risk chart electronical fomat

Because the risk is the sum of the risk factors, who are numerous and have an unequal impact on the basis of vertebral segment, calculating individual risk for each segment deflection would require a lot of time from the medical practitioner. For these reasons, we designed an application that works as a computer program.

The advantages of using computers are:

- Shortens the time for risk estimation

- Allows you to store long-term data comparing the dynamic risk and facilitates access to remote data

- Risk factors are preset so that the program becomes a guide for the doctor

- Allows creation of databases and then statistical processing to improve performance

The application uses Microsoft Excel (which is very popular). The interface includes patient identification fields and the risk factors studied individually or conditions profession and clinical examination. Some fields have preset content and let you choose from the list to not allow the user to type in information that might otherwise be encoded in the database. The program returns in real time, the risk calculated for each type of deformation possible from each level vertebral both visually as a progress bar and numerical (percentage expression of individual score relative to score the mathematical model and maximum likelihood prediction model), but also qualitatively, pointing through a blank yellow in the right type of deformation, when the individual score is over 1/3 of the score, or red if exceeded individual score 2/3 score.

The only limitation is given by the characteristics of mathematical models:

- Maximum power of predictive mathematical models resulting from statistical analysis
- Risk factors of significance for population groups whose profession is identical to one of the professions in the program list. Obviously, the application returns a risk score for subjects who do not have a similar profession, but the accuracy of calculation will be necunoscută.Aceste shortcomings can be improved by including the study of a large number of subjects.

CONCLUSIONS

1. The risk of spinal deformities is multifactorial.
2. The interaction between risk factors is not linear and uniform.
3. The same factor has a different potential risk when compared to different vertebral segments.
4. The best statistical method to quantify risk factors is through multivariate analysis. It examines and quantifies each individual risk factor through the interaction with other factors, compared with healthy subjects.
5. These mathematical models allow the forecast since the first contact with the subjects using simple and noninvasive elements - history, clinical examination.
6. The accuracy of prediction is dependent on the accuracy predictive mathematical model, and is all the better since the latter is higher.
7. The mathematical models will orient medical attention, by one or more vertebral segments with the potential for distortion, before it materialize. Thus, it allows the physician to bring additional preventive measures.
8.The mathematical models will allow the physician to watch dynamic risk (repeated while quantifying, individual risk of deformation). Such developments would show the improvement or worsening if necessary to intensify prevention measures or whether you should take extra care decisions (hospitalization, imaging complex investigations, interdisciplinary checkups, etc.). Practically oriented workplace conduct preventive and medical conduct.
9. The computerized application is very useful in practice, thereby allowing direct input of data helps the doctor not to overlook any of the risk factors, the calculation is done in real time (as data is entered) enables scenarios (as by modifying risk factors present amended) allows you to save and compare the results. Moreover, the application draws attention clinician to potential risk factor, even when entering data, they are marked with an asterisk.

DATE 14.10.2016

SHEET PROFESSIONAL RISK FOR SPINAL DEFORMITIES

NAME: EXAMPLE

DOCTOR:

WORKPLACE:

REG/FO

Age	61 *	Roland-Morris	0
Gender	f *	Scor VAS	0
Environment	u	Simptome	no
Height	160 (cm) *	Contracture	Cervical&Lumbar segment
Weight	75 (Kg) *	Cervical Segment	Normal
BMI	29,3 (Kg/m2) *	Dorsal Kyphosis	Normal
Profession	hairdresser *	Scoliosis Ridge	Dextroconvexa *
Age occupation	41 *	Lumbar Lordosis	Accentuated *
Addictions	former smoker and alcohol consumer	Lumbar Scoliosis	Dextroconcava
Sports	no	Menton-Stern Index	0
Education	high school *	Menton-Acromion Index	2
Family History	no	Ott Index	31 *
Hours Standing	7 *	Schobber Index	16
Hours Seated	1	Tragus-Acromion Index	0
Trunk Movements	twist	Wall Occiput Distance	0
Weight Lifting	no (Kg)	Index Fingers Ground	0
Carrying Weights	no (Kg)	Cervical Flexion	5
Working with Hands	yes	Cervical Extension	5
Vibration 2-20Hz	no	Lumbar Spine Extension	5
Work Environment	no	Inferior Lumbar Extension	4
Associated Pathology	SDAc&SDAlumbar&Osteoporosis *	Lumbar Spine Flexion	4 *
Sik Leave	0 (zile)	Lumbar Spine Rotation	4 *
Treatments	NSAIDs		

THE ESTIMATED RISK

●	THE ESTIMATED RISK FOR CERVICAL CURVATURE ACCENTUATION	0,00	**62,1** %
●	THE ESTIMATED RISK FOR CERVICAL CURVATURE DECREASE	8,16	**50,9** %
●	THE ESTIMATED RISK FOR EMPHASIZING DORSAL KYPHOSIS	19,63	**64,5** %
●	THE ESTIMATED RISK FOR DORSAL KYPHOSIS REDUCTION	2,83	**52,7** %
●	THE ESTIMATED RISK FOR DORSAL SCOLIOSIS RIGHT CONCAVE	1,10	**34,2** %
●	THE ESTIMATED RISK FOR DORSAL SCOLIOSIS RIGHT CONVEX	DEFORMED	**36,9** %
●	THE ESTIMATED RISK FOR PRONOUNCED LUMBAR LORDOSIS	DEFORMED	**96,8** %
●	THE ESTIMATED RISK FOR DIMINISHED LUMBAR LORDOSIS	7,53	**45,5** %
●	THE ESTIMATED RISK FOR LUMBAR SCOLIOSIS RIGHT CONCAVE	DEFORMED	**44,4** %
●	THE ESTIMATED RISK FOR LUMBAR SCOLIOSIS RIGHT CONVEX	3,80	**39,8** %

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