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Regression models in the assessment of the relationship between body posture in the sagittal plane and SEMG of the spine rectifier in children at a younger school age

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Abstract
The aim of the study was to create regression models for the analysis of the relationship between posture defects in the sagittal plane and SEMG of the spine rectifier in children with scoliotic lesions. The shape of the spine was assessed using the optoelectronic method Diers formetric III 4D. The SEMG analysis was performed using the Noraxon TeleMyo DTS 12 channel camera. The research was carried out in 2017 at the Posturology Laboratory at the

Faculty of Medicine and Health Sciences of UJK in Kielce. The most important and statistically significant predictor of the body posture in the sagittal plane and the frequency of the ridge extensor examined in various positions in the group of scoliotic postures turned out to be the variable lower limb up the right breast segment (p = 0.01). In the case of the SEMG amplitude, the most important and statistically significant predictors in the group of scoliotic attitudes turned out to be variable lower limbs upward lumbar segment right side (p = 0.02) and standing position lumbar segment left side (p = 0.03). The SEMG test enables the control of muscle balance and allows to avoid the improper deepening of muscle asymmetry, resulting in the stimulation of disturbing forces.

Key words: variable posture in the sagittal plane, scoliosis, scoliotic posture, Diers formetric III 4D

Introduction

Electromyographic examination (SEMG) allows you to control muscle balance and avoid the improper deepening of muscle asymmetry, resulting in the stimulation of forces that disturb the balance [1-6]. SEMG analysis can be used to effectively recognize correct, corrective postural defects in muscle work patterns [7-11]. It was found that asymmetric muscle activity is associated with increased axial rotation, which in turn is associated with an increase in the Cobb angle [12-18]. The SEMG examination also allows precise determination of motor functions in patients with motor dysfunctions, and enables the recording of natural signals of muscle activation [19-20]. The aim of the study was to create regression models for the analysis of the relationship between posture defects in the sagittal plane and SEMG of the spine rectifier in children with scoliotic lesions.

Material and Methods

The study involved 251 children including 113 girls (45.02%) and 138 boys (54.98%). Tehere were 130 (51.79%). seven-year-old children Among them there were 63 girls (48.46%) and 67 boys (51.54%). There were 121 (48.21%) eight-year-old children. Among them were 50 (41.32%) girls and 71 (58.68%) boys. The selection of respondents was mixed, after having established the criteria to be met by each group. The study was conducted in 2017 in Posture Laboratory, Faculty of Medicine and Health Sciences UJK in Kielce. All test procedures were performed according to the Helsinki declaration in force in 1964 and with the approval of the Bioethics Committee of the University of Jan Kochanowski University in Kielce (Resolution No. 5/2015). The body posture was assessed using optoelectronic Diers formetric III 4D. The study was conducted in the DiCAM by Average measuring, consisting in the taking the sequence of twelve pictures, which by creating the average value of the variances reduced the attitudes and thereby improve the value of clinical research. Scoliotic posture occurred when pelvic tilt was 1-5 mm, and at the same time, the lateral deviation was 1-5 mm, and surface rotation was 1-5 ° C. Scoliosis occurred when pelvic tilt, lateral deviation were greater than 5 mm (> 5 mm), and surface rotation was greater than 5 degrees (> 5 °). To assess the occurence of idiopathic scoliosis or scoliosis posture all three conditions had to be met. Rules based on the size of the angle of kyphosis and lordosis angle there were 9 types lumbar spine isolated:

- backbone with normal physiological curves: the angle of kyphosis: 42 ° -55 °; lumbar lordosis angle of 33 ° -47 °;
- reduced kyphosis and lordosis: the angle of kyphosis <42 °; lumbar lordosis angle <33 °;
- reduced kyphosis and correct lordosis: angle of kyphosis <42 °; lumbar lordosis angle of 33-47 °;
- reduced kyphosis and enlarged lordosis: angle of kyphosis <42 °; lumbar lordosis angle> 47 °;
- correct kyphosis and enlarged lordosis: angle of kyphosis: 42 ° -55 °; lumbar lordosis angle> 47 °;
- enlarged kyphosis and reduced lordosis: the angle of kyphosis: > 55 °; lumbar lordosis angle <33 °;
- enlarged kyphosis and correct lordosis: angle of kyphosis: > 55 °; lumbar lordosis angle of 33 ° -47 °;
- enlarged kyphosis and lordosis, plus: angle of kyphosis: > 55 °; lumbar lordosis angle of> 47.
- correct kyphosis, reduced lordosis: the angle of kyphosis: 42 ° -55 °; lumbar lordosis angle <33 ° [20].

Electromyographic analysis was performed using a 12-channel camera Noraxon TeleMyo DTS. The unit had a EC certificate (Certification Production Quality Assurance Directive 93/42 / EEC Medical Dewices Annex V). This product complies with the requirements

Dewices Medical Directive 93/42 / EEC for products of Class I possessed the appropriate CE mark. The product meets the definition of class I and class product standard. Safety: IEC 60601-1 (1988) and EMC IEC 60601-1-2. Gel electrodes were used having a diameter of 3 cm. By means of an electromyographic study, it was possible to show the relationship between muscle disorder and the appearance of other symptoms, in this case scoliosis. In addition, the analysis enabled neutral verification, qualitative assessment, and registration of the impact of interventions to improve muscle function. The skin of the subjects was cleaned with abrasive fluid at the point where the electrodes were applied. The electrodes were located parallel to the direction of the muscle fibers tested. The distance between them was about two centimeters. Erector spinae muscles were examined in the thoracic and lumbar, both on the left and the right. Each test lasted 10 seconds. Raw recording electromyographic signal was presented in the form of a bar chart. It takes into account the average frequency of the spine muscle tone expressed in hertz (Hz) and its median, as well as the mean amplitude of this muscle, expressed in microvolts (μV). On the Y axis is the voltage frequency, while on the X axis - the write time expressed in seconds. The test results take into account the scale of the intensity of the voltage interval that was 100 milliseconds. The study used a mode of continuous recording track. SEMG recording was performed directly on the skin. Functional potentials were recorded from the dorsal extensor in the thoracic and lumbar sections at the top of the curves of the curve:

1. in a habitual standing position(Frankfurt plane).
2. in the resting position: in the front facing(the lower limbs straightened in the knee joints, upper limbs placed along the trunk),
3. in isometric contraction conditions:

- in the frontal position (lower extremities straightened in the knee joints, upper limbs placed along the trunk, pelvis stabilized) the subject lifts the torso within the limits of the mobility of the spine, and then maintains it in this position for 10 second.
- in the frontal position, with the upper torso stabilized (shoulders and chest, limbs stacked as before) the subject lifts both lower limbs to the maximum possible height and maintains them for 10 seconds.The following parameters were analyzed electromyographic:

The following electromyographic parameters were analyzed:

- the average amplitude of the signal (correlates with the degree of muscle activity),
- area under the signal envelope (associated with the total muscle work),
- the average and middle frequency of the EMG signal spectrum (used to assess the degree of muscle fatigue along with the evaluation of changes in signal amplitude),

- time characteristic of muscle work (no arousal, constant activity, inappropriate stimulation - too early, delayed, too short, too long.

Measurement SEMG was in line with the recommendations of SENIAM (Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles), a European research program, containing a number of guidelines on the choice of the type of electrodes, their location, anatomy and function of muscle testing muscle groups as well as signal processing and terms of hardware. Both the study of posture and analysis of SEMG were painless and non-invasive. Before the beginning of the calculations, the Kolmogorov-Smirnov test was carried out to determine the normality of the distributions. To assess whether the variable postures in the sagittal plane differ significantly between gender and age category in scoliosis groups, scoliosis and norms, as well as whether its level between these groups differs significantly between girls and boys, as well as 7-year-olds and 8 -tanks, a one-way analysis of ANOVA variance was used. Multiple regression models, and progressive stepwise were used to determine the relationship and to determine the predictors for the dependent variables posture in the sagittal plane. Before regression analysis k-fold cross validation was performed. The verification parameter used to evaluate the models was the coefficient of determination, the corrected coefficient of determination and the test statistic and the level of statistical significance, which clearly allowed to select models with the assumed level of statistical significance, $p < 0.05$.

Results

In the scoliosis group, the most common were kyphosis and reduced lordosis (correct kyphosis, reduced lordosis) (23%), as well as reduced kyphosis and normal lordosis (23%) (reduced kyphosis, correct lordosis) (23%). In the group of scoliotic attitudes, the most common were reduced kyphosis and normal lordosis (reduced kyphosis, correct lordosis) (21%), as well as reduced kyphosis and increased lordosis (reduced kyphosis and increased lordosis) (21%). On the other hand, in the group of attitudes in the norm the most frequent were normal kyphosis and normal lordosis (correct kyphosis, correct lordosis (29%), as well as reduced kyphosis and increased lordosis (reduced kyphosis and increased lordosis) (29%) (Table 1).

The independent variables were the frequency and amplitude of the SEMG of the spine rectifier, while the dependent variables were the features of body posture in the sagittal plane. The regression model for the group with the norm and the group with scoliosis did not reach the assumed statistical significance, therefore it was not shown and was not considered correct in modeling the relationship between body posture variables in the sagittal plane and the frequency and amplitude of the spine rectifier tested in different positions. The most important and statistically significant predictor model for the body posture in the sagittal plane and the frequency of the spine rectifier examined in various positions in the group of scoliotic attitudes turned out to be the variable lower limb up the right breast segment ($p = 0.01$). The variance explained by the independent variables adopted in the model is 64% of the total volatility ($R^2 = 0.64$), which indicates a good fit to the data, the assumed statistical significance level ($p = 0.01$) was met and also the high statistical test value $F = 9.46$ (Table 2). The regression model for the group with the norm and the scoliosis group did not reach the assumed statistical significance, therefore it was not shown and was not considered correct in modeling the relationship between body posture variables in the sagittal plane and the amplitude of the ridge extensor examined in different positions. In turn, the most important and statistically significant predictors of the model for the body posture in the sagittal plane and the amplitude of the ridge extensor examined in different positions in the group of scoliotic postures turned out to be variable lower limb upward lumbar segment right side ($p = 0.02$) and standing position left lumbar section page ($p = 0.03$). The variance explained by the independent variables adopted in the model is 29% of the total volatility ($R^2 = 0.29$), which indicates a small adjustment to the data, however, the assumed statistical significance level ($p = 0.02$) was met and also the appropriate statistical test F was obtained = 3.02 (Table 2).

Discussion

Scoliosis is one of the biggest problems in the field of orthopedics. The accompanying disorders of muscle balance, and in particular the muscles of the extensor muscles, have a definite effect on the progressive character of the curvature. One of the studies used to record the work of this muscle group is surface electromyography. The flattening of thoracic kyphosis and lumbar lordosis results in a partial or complete transfer of the loads associated with vertical body posture to small, stiff, oblique or even vertically aligned joints, making the system unstable. Flattening the back makes the spine labile and susceptible to lateral deflections. Properly shaped physiological curvature of the spine protects it against the occurrence of lateral curvatures [21]. The flattening of thoracic kyphosis and lumbar lordosis is rightly considered as predisposing factors for progressive idiopathic scoliosis. The size of physiological thoracic kyphosis and lumbar lordosis should be considered in the selection of scoliosis treatment methods [58]. From the beginning of research on electromyography of the spinal muscle muscle, it was noticed that there is a relationship between spinal curvature and unequal muscle tension in the extensor muscles [22]. Therefore, the goal of scoliosis therapy should be to restore proper relations between the vertebrae so that the distribution of pressing and shearing forces will burden the vertebral bodies, not the joint processes [23]. Passive stabilizing structures, such as: intervertebral discs, interstitial joint bags, ligaments, are not able to ensure correct segmental stabilization in the sagittal plane [24]. Muscle dystonia, which occurs in children with scoliosis, causes destabilization and additional burden on these structures. Only the introduction of neuro-muscular origin forces reduces the dislocations in the sagittal plane [25].

Conclusions

The most important and statistically significant predictor of the body posture in the sagittal plane and the frequency of the ridge extensor examined in various positions in the group of scoliotic postures turned out to be the variable lower limb up the right breast segment ($p = 0.01$). In the case of the SEMG amplitude, the most important and statistically significant predictors in the group of scoliotic attitudes turned out to be variable lower limbs upward lumbar segment right side ($p = 0.02$) and standing position lumbar segment left side ($p = 0.03$). The regression model for the group with the norm and the scoliosis group did not reach the assumed statistical significance, therefore it was not shown and was not considered correct in modeling the relationship between body posture variables in the sagittal plane and the amplitude of the ridge extensor examined in different positions. The SEMG test enables the control of muscle balance and allows to avoid the improper deepening of muscle asymmetry, resulting in the stimulation of disturbing forces.

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Table 1. Types of posture

Types of posture	Total	Scoliosis	Scoliotic posture	Correct posture
Reduced kyphosis, correct lordosis	**54 (22%)**	**24 (23%)**	**29 (21%)**	1 (14%)
Reduced kyphosis and increased lordosis	**44 (18%)**	13 (13%)	**29 (21%)**	**2 (29%)**
Reduced kyphosis and reduced lordosis	15 (6%)	7 (7%)	8 (6%)	-
Correct kyphosis, reduced lordosis	**51 (20%)**	**24 (23%)**	**26 (18%)**	1 (14%)
Correct kyphosis, enlarged lordosis	24 (10%)	7 (14%)	16 (11%)	1 (14%)
Correct kyphosis, correct lordosis	**44 (18%)**	14 (14%)	**28 (20%)**	**2 (29%)**
Increased kyphosis, correct lordosis	10 (4%)	6 (6%)	4 (3%)	-
Increased kyphosis, correct lordosis	6 (2%)	5 (5%)	1 (1%)	-
Increased kyphosis and increased lordosis	3 (1%)	3 (3%)	-	-

Table 2. A stepwise regression model for the posture of the body in the sagittal plane and SEMG of the spine rectifier

A stepwise regression model for the body posture in the sagittal plane and the SEMG frequency of the spine rectifier[1]						
Variable	b*	Std. Error Z b*	b	Std. Error Z b	t (100)	*p*
W. free			55.15	4.76	11.59	0.00
Lower limbs up chest segment right side	-0.64	0.21	-0.18	0.06	-3.08	0.01
R= 0.64; R^2 = 0.40; Correction R2 = 0.36; F (1.14) = 9.46; p=0.01						

1 * b - constant regression, Std. Error Z b* - standard error of the regression constant; b – the partial regression coefficients, Std. Error Z b - standard error of the partial regression coefficient, t – statistical test, p - level of significance

A model of stepwise regression progressing for the body posture in the sagittal plane and the amplitude of SEMG of the spine rectifier						
Variable	b*	Std. Error Z b*	b	Std. Error Z b	t (95)	*p*
W. free			47.53	3.21	14.79	0.001
Lower limbs up the lumbar segment right side	-0.23	0.09	-0.07	0.03	-2.45	0.02
Standing standing lumbar segment left side	0.23	0.10	0.18	0.08	2.24	0.03
R= 0.29; R^2 = 0.08; Correction R2 = 0.06; F (4.134) = 3.02; p=0.02						