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Application of thermography in diagnostics and prognostication of scoliosis treatment

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The paper deals with the thermography applied to monitor the course of scoliosis treatment. In the research, 403 children and teenagers in the 9–17 age range (m = 13.4) were examined.

The orthopaedic and thermovision examination was carried out once in the group of healthy children, whereas the children with the spine curvature, undergoing conservative and operative treatment, were examined orthpeadically, roentgenographically and thermovisionally before and after the treatment. Cobb's method and the Gruca categorisation of the degree of scoliosis were employed to assess the type and the level of the primary and the secondary curvature.

The analysis of the thermographic pictures was carried out using the computer program for such an analysis of the back in relation to mechanic and anatomic axis of the spine. The results were analysed statistically and presented in the form of histograms.

Based on the research, the thermographic model of the back and spine was constructed. The relation between the degree of the primary and the secondary curvature and the pattern of temperature distribution of the back was found as well as the thermographic features characteristic of the development of the scoliosis were identified.

Key words: thermography, scoliosis treatment, thermographic model

1. Introduction

Despite the continuous development of research and prevention methods as well as diagnostic and treatment technique, the lateral curvature of the spine, which is also called scoliosis, still remains a serious medical problem of developmental age medicine. This, in turn, results from the lack of simple non-invasive, but accurate diagnostic methods designed to enable examination of large groups of people and evaluation of the defect development as well as the results of its conservative and operative treatment [1], [3], [4], [5], [8], [10].

The thermovision method of very accurate non-invasive measurement of thermal radiation emitted by an object being examined is commonly considered to be one of the safest for a patient.

Based both on the analysis of the relevant literature and our own experience, it was hypothesized that the change in the symmetry of the temperature distribution in the back area of the trunk, especially in its paraspinal part caused by the disorders of metabolism and the functions of the paraspinal muscles, is one of the first symptoms of pathological anatomical and mechanical changes.

2. Purposes

1. Determining the distribution of temperature along the entire spine axis in order to construct the thermal model.
2. Assessing the effect of a particular body posture on the distribution of temperature along the spine axis in healthy children.
3. Evaluating the identified temperature differences in relation to the type of scoliosis.
4. An attempt to identify thermal parameters determining progression of scoliosis.
5. Evaluating the usefulness of the thermography for monitoring the course of conservative and operative treatment of scoliosis.

3. Material and method

The research was carried out in the Rehabilitation Clinic of Lublin Medical University, the Orthopaedic and Rehabilitation Clinic for Children and Adolescents of the Medical College of the Jagiellonian University in Zakopane and the Chair of Physiotheraphy of Wrocław University School of Physical Education. Moreover, in a part of the research, 118 pupils of a Primary School No. 5 in Mikolow took part. They constituted a control group. In general, there were 403 subjects, whose age ranged from 6 to 17 years, 14.013 years on an average. The height of the participants varied from 105 to 185 cm and their weight – from 23.3 to 112 kg; the relevant average values were 157 cm and 47.6 kg. The BMI index for the entire population was 17.7.

Taking into account the type of scoliosis, the children suffering from the lateral idiopathic curvature of the spine were divided into the groups with the single- and double-curves scoliosis as well as the subgroups with the 1^{st}, the 2^{nd} and the 3^{rd} curvature degree (as categorized by Gruca), treated both conservatively and operatively.

The orthopaedic and thermovision examinations were carried out under constant and standard conditions; the healthy children were examined only once, whereas those suffering from the scoliosis were treated both in the conservative and operative way and underwent several orthopaedic, roentgenological and thermovision tests.

The thermographic analysis of the back in relation to the anatomic axis of the spine was realized in collaboration with MS Robert Koprowski from the Chair of Computer Control Systems of the Institute of Computer Science directed Dr. Zygmunt Wróbel.

The computer program analyses a thermal picture through calculating, every 5–7 mm, the average temperature of the 10 piksels along both sides of the vertical line of automatically or manually determined spine axis.

4. Results

The thermograms presented as the standard pattern of the control group with correct body posture and of the group made up of the children affected by double-major curves of the spine are shown in figures 1 and 2. In the control group, the average difference in temperature between concave and convex sides of the spine reached 0.314 °C with the median of 0.317 °C. The greatest difference in the temperature between both sides of the spine amounted to 0.5 °C. Table 1 shows the results of the thermographic examinations of the children with idiopathic curvature and the children from control group. In the children with a single-curvature of the spine, the thermal curve tends to be flat compared with the even, parabolic course of the standard curve in the group of healthy children.

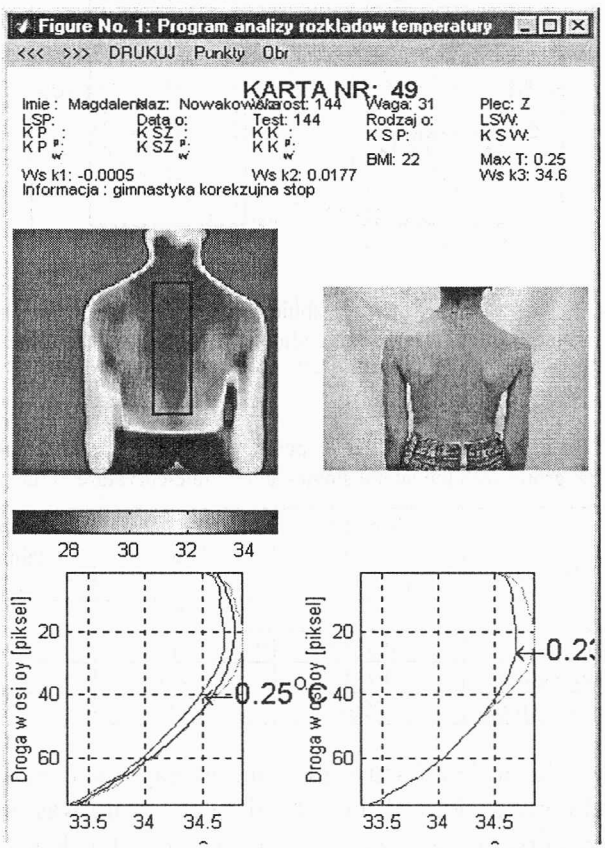

Fig. 1. The examplary thermographic model of the back

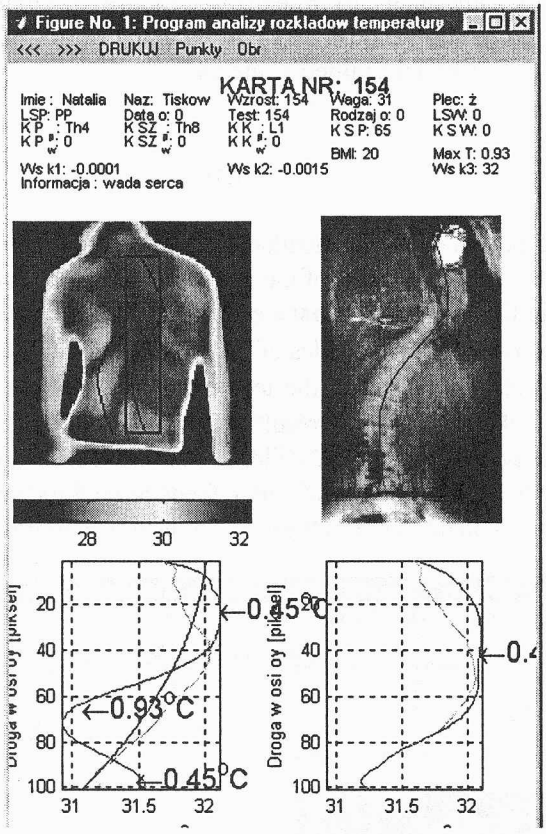

Fig. 2. The examplary thermographic model of the back in the group with the lateral double-curve idiopathic scoliosis of the spine

Table 1. The average values of the temperature differences in the control group and the group with the lateral single- and double-curvature of the spine

Groups	Average temperature difference	Median	Maximum temperature difference
	°C		
Control group	0.314	0.317	0.5
Single-curvature group	0.724	0.625	1.7
Double-curvature group	1.0964	0.95	2.75

In the children with a double-curvature, the average temperature difference between concave and convex sides of the secondary curvature was twice as great as in the case of primary curvature and amounted to 0.5 °C. The shape of thermal curves along the entire spine was asymmetrical and, like in the single-curvature subgroup, flatter compared to the standard curve determined on grounds of the results provided

by the group of healthy children. The values for the idiopathic single- and double-curvature groups proved to be twice as high as the ones for the control group. The relevant temperature difference between the single- and double-curvature children reached 30%.

Table 2. The average values of the temperature differences in the control group and the groups with the lateral curvature of the 1st, the 2nd and 3rd degrees according to Gruca's categorisation

Groups	Average temperature difference	Median	Maximum temperature difference
	°C		
Control group	0.314	0.317	0.5
The 1st degree-curvature group	0.832	0.665	1.7
The 2nd degree-curvature group	0.999	0.81	2.6
The 3rd degree-curvature group	1.336	1.34	2.8

The results of the thermographic tests for the children that suffer from scoliosis and healthy children are shown in table 2. The comparison of the average differences in temperature, median and maximum temperature gaps between concave and convex sides of the curvature revealed that the increase in the curvature was accompanied by the continuous growth of the temperature divergence, which may attest to the rise in the metabolism disorders of the tissues located in this area as well as the increase in the discrepancy in the tonus of back muscles.

5. Discussion

According to the previous research, the genesis and development of the lateral curvature of the spine depend on etiological and biomechanical factors. Its etiology, which determines the appearance of the curvature and the biomechanics of the spine axis, is varied and has not been fully explained. The pathomechanic factor has an important effect on the development and course of the curvature as a result of the disturbance of the muscle balance.

The symmetric distribution of temperature in the back testifies to regular metabolism and balanced tension of the muscles which stabilize the spine. The preliminary analysis of the healthy children's thermographs shows that the temperature distribution along the mechanic and anatomic thermal axis of the entire spine is symmetrical. The theory of the asymmetry of muscular tonus was confirmed by the results obtained from the thermographic examination of the healthy children. This examination explained how the thermal picture was influenced by the posture the children held. The shape and course of the thermal curve, which are very similar to the shape and course of the thermal curves recorded within the whole group of healthy children, indicate

that a small change in the symmetry of tonus of healthy stabilising muscles does not cause the change of temperature distribution reflecting the metabolic processes taking place in the muscular tissue.

The disorder in muscular tonus and metabolism on one side of the spine leads to back muscles balance disorder, which, in turn, results in the balance and statics disturbances of the trunk and increased curvature [7], [8]. The disturbance and asymmetry of the active muscle tonus on the concave and convex sides affect the development of curvature. The research revealed the negative correlation between temperature differences on either side of spine within both primary and secondary curvatures. The rise in temperature indicating more rapid metabolism and better active tonus of muscles (and their contracture in the distant future) on the concave side of a curvature is accompanied by the drop in temperature and worse muscle tonus on its convex side. The results obtained by investigating the relation between the extent of curvature determined by means of the roentgen method and the thermal picture of the back were ambiguous. The increase in the angle of primary curvature was not accompanied by the significant change in the shape and course of the thermal curves as it was the case with the difference in the average temperature between the concave and convex sides.

In the 1st degree curvature (as categorized by Gruca) group, the course of the thermal curves was asymmetric with the temperature difference between the concave and the convex sides of curvature ranging from 0.5 do 1.7 °C, 0.83167 °C on an average. The shape of the curves in the 2nd degree curvature group was not different, but the temperature gap between the concave and convex sides of the primary curvature was almost twice as large as in the former group, varying from 1.05 to 1.5 °C, 1.2 °C on an average.

The evaluation of the effect the applied treatment had on biomechanics and functioning of muscles allowed us to conclude that owing to a series of exercises the temperature of the convex side of curvature rose and neared the level observed on the concave side. The effect was even more visible after a series of asymmetric exercises, where an average difference in temperature following the series was 0.1 °C; three times as low as in the group performing symmetrical exercises.

The application of a long stabilisator in the group of children, who underwent the operative treatment, considerably stiffened the spine leading to the reduction in muscle tone manifesting itself in the decrease of the temperature difference on the concave–convex side.

6. Conclusions

1. The results of the research allowed us to set the model thermographic features for the healthy group. The maximum difference in the average temperature between the left and the right sides of the normal thermographic picture of the back should not exceed 0.5 °C. The curves representing the average temperature on both sides of the

thermographic axis of the spine should take the shape of a regular reversed parabola with the highest temperature ranging from 33 to 35 °C in the upper part of the spine and the lowest one from 31.5 to 32.5 °C in its bottom part. The difference in the average temperature between the upper and the bottom parts of the spine should not exceed 4.3 °C. The difference may indicate the better tonus of the muscles stabilizing the pectoral segment compared with the lumbar one. The muscle balance disorder would result from the excessive increase of this gap. Further research is needed, however, to test this hypothesis.

2. The results obtained show that the forced shaping of correct spine axis has no effect on the distribution of temperature in the back part of the trunk.

3. The larger the deformation of spine, the bigger the difference in temperature between the concave and convex sides of the primary curvature, and the temperature curve becomes flat.

4. The results lead to the conclusion that the development and the course of curvature may be determined by the changes of temperature differences as a function of time, whereas the muscle dystonia is reflected in the shape of the temperature curve and, most of all, the temperature difference between the concave and convex sides of the curvature.

5. The thermography method is very useful, especially in the case idiopathic scoliosis, for the evaluation of conservative treatment by exercising muscles.

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