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THERMAL IMAGING SIGNS OF SPASTIC FORMS OF CEREBRAL PALSY IN CHILDREN 4-7 YEARS: PRELIMINARY RESULTS

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Introduction

Cerebral palsy (CP) affect on the neuromuscular system is manifested in spasticity, contractures, pain syndromes, muscle weakness, loss of selectivity, impaired postural control, pattern, and impaired standing balance. One of the promising diagnostic methods for motor disorders is the measurement of skin temperature using thermal imaging. The more detailed description of the temperature manifestations of spasticity in CP is still required. There is not enough data on the mechanisms of the formation of pathological thermal patterns with the relation to the degree of movement disorders.

Hypothesis

We assumed that with long-term spastic disorders in the motor sphere characteristic of CP, the IR radiation from the suffering muscle groups will be reduced, and their response to the motor load differs from the reaction of healthy muscles.

The aim was to study the stationary distribution of thermal fields on the body surface and their dynamics after moderate physical activity in children with spastic forms of cerebral palsy.

Methods

The study includes 31 patients with CP and functioning at Gross Motor Function Classification System (GMFCS) levels I or II aged 4-7 years old. CP was identified using ICD-10 codes G80.1 - spastic diplegia (17 children: 12 patients with lower paraparesis, 5 with upper paraparesis), G80.2 - hemiplegic form (14 children). 9 children without disabilities of the same age served as the control group. The study was approved by the local ethics committee of the PIMU (protocol No.4 from 03/29/2017). Informed consent was obtained from parents and/or the legal guardians.

The thermal image was observed by a thermo-tracer (NEC TH-9100) with a temperature resolution of 0.06K. The measurements followed the protocols of thermal imaging studies [1], with our modification of the positions. Our own active infrared thermal mapping technique has been applied [2]. The technique includes the registration of thermal maps of 67 regions of interest (ROIs) on the trunk, upper and lower limbs, and face, before and after the motor load. Standard protocol complex biomechanical testing served as a functional motor load for all groups of children consisted of: 1. Holding a vertical posture on the ST-150 stability platform, the test duration is 60 s. 2. 2 passes along the track of the Tekscan Walkway podographic system, the duration is 2-5 minutes. 3. 2D video analysis of movements on the Simi Reality Motion Systems GmbH motion capture system (2 passes of 3 m on the left and right sides), the test duration is 10-15 minutes. 4. Performing the Nine-hole Peg Test [Smith et al., 2000] with dominant and non-dominant hands, the duration of execution is 5-15 minutes. The time to complete tests 2-4 varied depending on the capabilities of each child. The total time, taking into account pauses for the transition from one task to the next, was 30-45 minutes. The condition was the mandatory completion of each task and a clear sequence of tests.

For data processing and analysis, were used MS Excel 2010, Statisitica 12 software, and RStudio integrated development environment. The type of distribution of the studied parameters was determined by the Shapiro-Wilk test. The level of significance of differences for indicators with a nonparametric distribution was assessed by the Mann-Whitney test (w), for indicators with a normal distribution - by the Student's t-test for unrelated samples (t). The statistically significant p value was set as $p \geq 0.05$.

Results and discussion

The distribution and dynamics of temperatures on the face and the trunk proved to be uninformative. An analysis of thermal patterns of back revealed a distinction of the diplegia group from the control and the hemiparesis groups in the form of a temperature difference between the thoracic and lumbar regions ≥0.5°C; the greater temperature difference, the more severe paresis at the corresponding level.

Absolute temperatures and distal-proximal gradient (DPG) on the limbs. In the control group in all ROIs, thermal maps were typical of children of this age both initially (before the load) and after the load. In the diplegia group, initially, there was a distinctive DPG inversion in the front surface of the lower limbs, namely shin/foot segments with increase in temperature to distal direction, and on the inner surface of the upper limbs in the shoulder/forearm segments. In the hemiparesis group, there are significant differences in initial absolute temperatures on the following ROIs: hemiparesis and the control - the back of the wrists; hemiparesis and diplegia - the back of wrists and the

projection of the ankle joints. After the load, there are significant differences in the following ROIs: diplegia and control - the back-inner surface of the shin; hemiparesis and diplegia - the projection of the ankle joints and the back-inner surface of the shin. The dynamics at the stages is useful for evaluating the compensatory muscle resources.

Thermal asymmetry (TA). Both initially and after loading, TA in the control group did not exceed 0.4°C in all segments and in all pairs of symmetrical ROIs. There were no significant differences in TA in the diplegic group from the control group. In the hemiparesis group observed a decrease in temperature on the affected side, emphasized in the projection of the most suffering muscle groups. After the load, an increase in TA was recorded in these patients, while in a number of ROI with initial values within typically normal limits, the compensation was disrupted. The pattern of these changes is promisingly correlated with problem muscles, which is especially important in the demanding conditions of activity and the environment.

Conclusion

Thermal imaging is an objective method for assessing the functional state of the thermoregulatory system, reflecting the degree of motor impairment in the form of deviations from the normal thermal pattern of the skin over affected muscle groups and temperature reactions to moderate dosed motor loads. The study revealed thermal imaging markers of the functional state of spastic muscles determined by the adaptive-compensatory reserves of their blood supply and thermoregulation. Patients with hemiparesis (G80.2) have characteristic TA on the affected side. For diplegia (G80.1), the inversion of normal DPG on the limbs is present. The intensity of thermal anomalies is individual, the general pattern is the decrease in temperature on the affected side at the corresponding level. Moderate motor load enhances thermal anomalies in both groups by further decrease in temperature in the projection of the affected muscles.

Knowledge of the thermal reactions of the skin in the projection of spastic muscles in response to stress tests opens up a potential opportunity for using the method in solving problems such as the selection of target ("key") muscles in botulinum therapy, and in general in assessing the course of treatment and rehabilitation of patients with CP. The search and analysis of thermal imaging signs of normalization of peripheral thermoregulation in the process of rehabilitation is a priority for further research in this direction. To achieve this, it is necessary to strive to increase the sample of patients and to increase the homogeneity of the groups.

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