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Abstract

For rehabilitation effectiveness assessment, a comprehensive examination using standardized questionnaires and infrared thermal imaging was performed in 20 children aged 5-8 years with spastic forms of cerebral palsy. The rehabilitation was carried out for one year and included inpatient and outpatient treatment both in clinic and at home. The possibilities of thermal imaging monitoring of treatment have been demonstrated. An attempt has been made to explain cases of mismatch between thermal imaging and clinical assessment of results. The proposed approach has a potencial for creating a reliable, convenient, non-invasive, and high-precision thermal imaging method for validating standardized clinical questionnaires.

Introduction

Spasticity is one of the leading clinical symptoms of spastic forms of cerebral palsy (CP), which can also lead to the development of secondary musculoskeletal problems [1]. In addition to the clinical standardized questionnaires [2], neurophysiological and biomechanical instrumental methods are typically used for spastic syndrome assessment. Thermal imaging has indisputable advantages allowing this technique to occupy its own place among the methods for motor disorders objectifying in children with spastic forms of CP [3,4].

Methodology

20 children aged 5-8 years with spastic forms of cerebral palsy and functioning at Gross Motor Function Classification System (GMFCS) levels I or II participated in the study. CP was identified using ICD-10 codes G80.1 – diplegia (10 children) and G80.2 – hemiplegia (10 children). The research was conducted at the University Clinic of the Volga Research Medical University of the Ministry of Health of Russia from 2017 to 2019, and had first been approved by the local ethics committee (protocol No.4 from 29.03.2017). Informed consent was obtained from parents and/or the legal guardians.

The rehabilitation was carried out for one year and included treatment in a clinic (14 days courses twice a year), outpatient (10 days courses of massage twice or thrice a year, botulinum therapy), and at home (daily exercises recommended by the doctor). The complex included exercise therapy, kinesitherapy, mechanotherapy, physiotherapy and reflexology, massage, classes with a speech therapist and defectologist, and pharmacotherapy if necessary.

To objectify the evaluation points of the determinants, specialized questionnaires and scales were used: GMFCS, MAS, visual analogue scale (VAS), GMFM-88, MACS.

The thermal image was observed by a thermo-tracer (NEC San-ei, TH-9100, Japan). Our own active infrared thermal mapping technique has been applied [5]. A detailed description of the active infrared thermal mapping technique: preparing patients for examination, selecting regions of interest (ROIs), performing a functional test (30 minutes of controlled motor load on spastic muscle groups during biomechanical measurements), recording and analyzing data, – is provided in our article [6].

For data processing and analysis we used MS Excel 2010 software and RStudio integrated development environment.

Results and discussion

A comprehensive clinical assessment of one-year rehabilitation using specialized questionnaires served for the neurologist report as criteria for evaluating whether there are improvements or not.

Obtained at the first stage of the experiment, thermal imaging markers of each of the two spastic forms of CP served as the starting point for analyzing the changes achieved during rehabilitation: the difference of the thermal asymmetry (TA) and the distal-proximal gradient (DPG) on the limbs before and after the motor load calculated at the beginning of rehabilitation and after one year of treatment. The patients with hemiparesis were considered to be improving in case of decrease in TA in the distal segments of the limbs to less than 0.5°C. The patients with diplegia – decrease in the inverted DPG or its change to the normal values direction. Table one demonstrates the comparison of treatment results according to clinical questionnaires and thermal imaging.

Table 1. *Comparison of treatment results according to clinical questionnaires and thermal imaging*

Patient ID	Diagnosis	Side / Paresis Level *	Improvement (●) / Without improvement (■) / No Tendency (●/■)			
			MAS	GMFCS	Neurologist Report	Thermal Imaging
101	G80.2	Right	■	■	■	■
102	G80.2	Right	■	■	■	■
105	G80.2	Right	●	■	●	●
106	G80.2	Left	■	■	●	●/■
108	G80.2	Right	●	●	●	■
109	G80.2	Right	■	■	■	■
113	G80.2	Right	●	■	●	●/■
118	G80.2	Right	■	■	■	■
120	G80.2	Left	●	■	●	●
124	G80.2	Left	■	■	●	●/■
110	G80.1	Lower limbs	■	■	●	■
111	G80.1	Lower limbs	■	●	●	●/■
115	G80.1	Lower limbs	●	■	●	●
116	G80.1	Lower limbs	●	■	●	●/■
119	G80.1	Upper limbs	■	■	■	●
122	G80.1	Lower limbs	●	■	●	●/■
125	G80.1	Lower limbs	●	●	●	●/■
126	G80.1	Upper limbs	■	■	●	●/■
127	G80.1	Lower limbs	■	■	■	■
128	G80.1	Lower limbs	■	■	●	●/■

*a child with G80.1 (diplegia) can have spasticity in both the lower and the upper limbs. Here the diagnosis was established in limbs where spasticity prevailed before the treatment.

Note: for thermal imaging evaluations, 'without improvement' rather means worsening of metrics.

The discrepancy between the results of clinical and thermal imaging analyses can be explained by the use of a large number of rating scales taking into account subjective assessment of contextual parameters of life. The observed temperature dynamics trends before the rehabilitation and after one year of treatment provide objective ground for their proof in subsequent studies.

Conclusion

Thermal imaging advantages allow this technique to occupy its own place among the methods for motor disorders objectifying in children with spastic forms of CP. With a significant increase in the sample size for a more thorough analysis, we believe that thermal imaging can be used as a means of validating clinical questionnaires in the future. The data obtained is promising in terms of objectification of neurological practice and improving the accuracy of the prognosis of the development of the disease, and the correction of comprehensive rehabilitation programs for spastic forms of CP.

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