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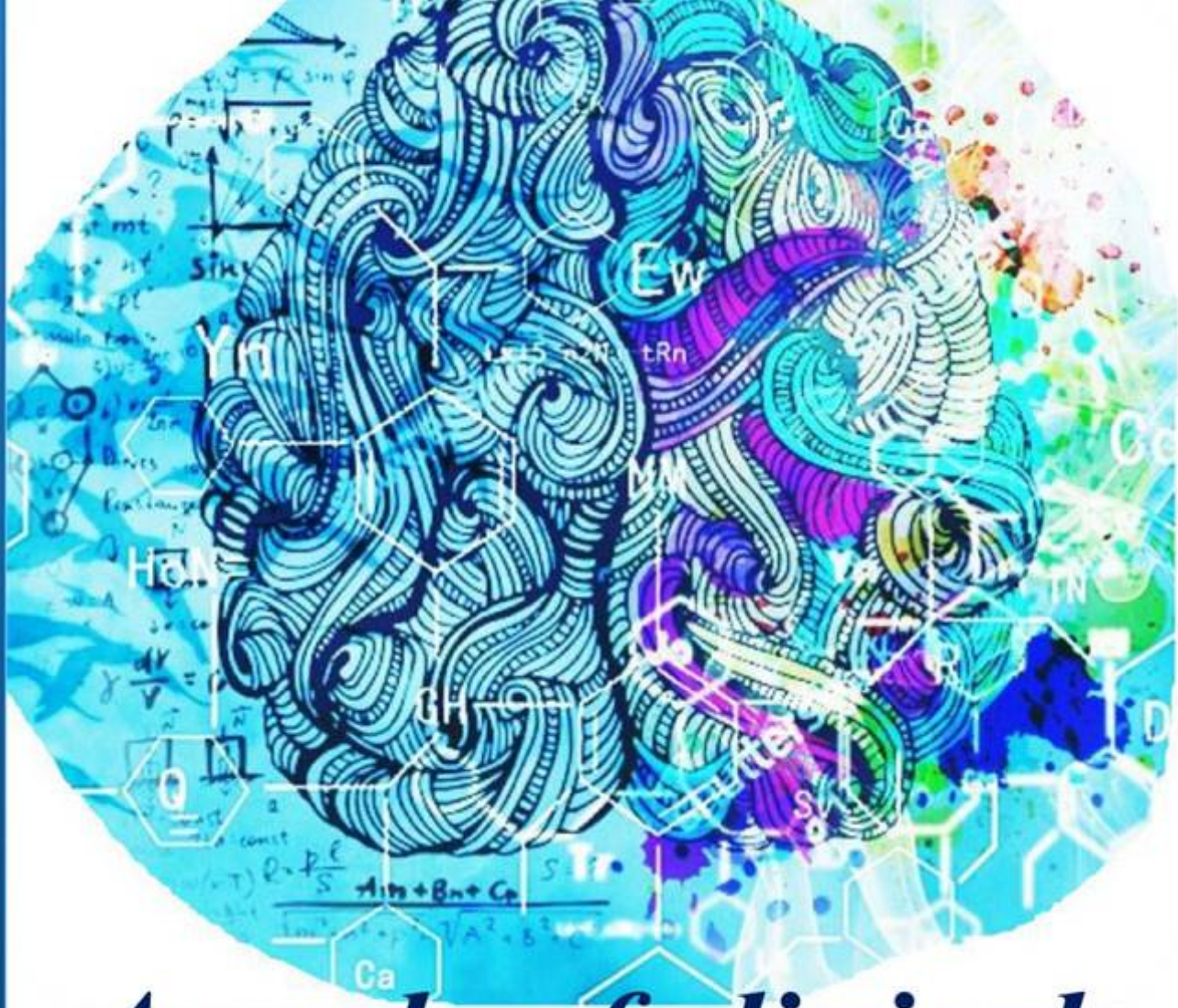

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STRUCTURAL AND FUNCTIONAL REMODELING OF SKELETAL MUSCLE AFTER BOTULINUM THERAPY IN CHILDREN WITH CEREBRAL PALSY (clinical and physiological study)

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Annotation. The aim of the study was to investigate structural and functional changes in skeletal muscle after botulinum therapy in children with cerebral palsy (CP) based on clinical, electrophysiological, and functional parameters. A prospective clinical and physiological study was conducted with assessment of spasticity dynamics, motor function, and electromyographic characteristics of target muscles before and after administration of botulinum toxin type A. The obtained data indicate that botulinum therapy initiates a complex remodeling of skeletal muscle, including reduction of pathological activity, decreased muscle co-activation, and functional remodeling, thereby creating conditions for the restoration of motor patterns and improving the effectiveness of rehabilitation.

Keywords: cerebral palsy, botulinum therapy, skeletal muscle, structural and functional remodeling, EMG, spasticity.

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СТРУКТУРНО-ФУНКЦИОНАЛЬНАЯ ПЕРЕСТРОЙКА СКЕЛЕТНОЙ МЫШЦЫ ПОСЛЕ БОТУЛИНОТЕРАПИИ У ДЕТЕЙ С ДЕТСКИМ ЦЕРЕБРАЛЬНЫМ ПАРАЛИЧОМ (клинико-физиологическое исследование)

Аннотация. Целью исследования явилось изучение структурно-функциональных изменений скелетной мышцы после ботулинотерапии у детей с детским церебральным

параличом (ДЦП) на основе клинических, электрофизиологических и функциональных показателей. Проведено проспективное клинико-физиологическое исследование с оценкой динамики спастичности, двигательной функции и электромиографических характеристик мышц-мишеней до и после введения ботулинического токсина типа А. Полученные данные свидетельствуют о том, что ботулинотерапия инициирует комплексную перестройку скелетной мышцы, включающую снижение патологической активности, уменьшение коактивации мышц и функциональное ремоделирование, что создаёт условия для восстановления двигательных паттернов и повышения эффективности реабилитации.

Ключевые слова: детский церебральный паралич, ботулинотерапия, скелетная мышца, структурно-функциональная перестройка, ЭНМГ, спастичность.

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BOLALAR SEREBRAL FALAJIDA BOTULINOTERAPIYADAN SO'NG SKELET MUSHAGINING STRUKTURAVIY VA FUNKSIONAL QAYTA TUZILISHI (klinik-fiziologik tadqiqot)

Annotatsiya. Ushbu tadqiqotning maqsadi bolalar serebral falajida (BSF) botulinoterapiyadan so'ng skelet mushagida yuzaga keladigan strukturaviy va funksional o'zgarishlarni klinik, elektrofiziologik hamda funksional ko'rsatkichlar asosida o'rganishdan iborat. Spastiklik dinamikasi, harakat funksiyasi va nishon mushaklarning elektromiografik xususiyatlari botulin toksini A turini yuborishdan oldin va keyin baholangan holda prospektiv klinik-fiziologik tadqiqot o'tkazildi. Olingan ma'lumotlar botulinoterapiya skelet mushagida patologik faollikning kamayishi, mushaklararo koaktivatsiyaning pasayishi va funksional qayta tuzilishni o'z ichiga olgan murakkab remodellashtirish jarayonlarini boshlab berishini ko'rsatdi. Bu esa harakat naqshlarini tiklash va reabilitatsiya samaradorligini oshirish uchun qulay sharoitlar yaratadi.

Kalit so'zlar: bolalar serebral falaji, botulinoterapiya, skelet mushagi, strukturaviy va funksional remodellashtirish, EMG, spastiklik.

Introduction. In cerebral palsy, skeletal muscle represents a secondary but crucial component of the pathological process. Chronic spasticity leads to persistent structural changes in muscle tissue, including shortening of muscle fibers, fibrosis, altered muscle fiber type composition, and impaired neuromuscular transmission.

Botulinum toxin type A is widely used for the correction of spasticity; however, its effects on the structural and functional state of skeletal muscle remain a subject of discussion. Current evidence suggests that botulinum therapy produces not only a temporary muscle-relaxing effect but also triggers functional and tissue remodeling processes, which are of fundamental importance for long-term treatment outcomes.

Aim and Objectives of the Study.

Aim. To investigate structural and functional remodeling of skeletal muscle after botulinum therapy in children with cerebral palsy based on clinical and physiological indicators.

Objectives

1. To assess changes in spasticity and motor function following botulinum therapy.
2. To analyze changes in electromyographic parameters of target muscles.
3. To study the characteristics of functional remodeling of skeletal muscle.

4. To identify clinical factors influencing the degree of muscle adaptation.
5. To determine the role of botulinum therapy in comprehensive rehabilitation of children with cerebral palsy.

Materials and Methods

Study Design

A prospective clinical and physiological study.

Patient Characteristics

Table 1. General characteristics of the examined patients

Parameter	Value
Number of patients (n)	48
Age, years (mean ± SD)	8.1 ± 2.3
Age range	5–12
Sex	29 boys / 19 girls
Form of CP	Spastic diplegia – 30; hemiplegia – 12; mixed – 6
GMFCS level	II – 16; III – 20; IV – 12

Inclusion Criteria

- Confirmed diagnosis of cerebral palsy
- Presence of focal spasticity (MAS ≥ 2)
- No botulinum therapy within 6 months prior to the study

Treatment Methods

Botulinum therapy was performed using botulinum toxin type A with ultrasound and/or electromyographic guidance.

Target muscles:

- m. gastrocnemius
- m. soleus
- m. tibialis posterior
- m. adductor longus

The total dose ranged from 2 to 6 U/kg of body weight, depending on clinical presentation and patient body mass.

Assessment Methods

Clinical Assessment

- Modified Ashworth Scale (MAS)
- Gross Motor Function Measure (GMFM-66)

Electromyography

- Surface EMG
- Needle EMG
- Analysis of amplitude, discharge frequency, and muscle activation patterns

Assessment Time Points

- Before botulinum therapy
- 12 weeks after administration

Results

Clinical Outcomes

Table 2. Dynamics of clinical parameters

Parameter	Before treatment	After 12 weeks	p
MAS (points)	3.0 ± 0.5	1.9 ± 0.4	<0.01
GMFM (%)	47.2 ± 6.9	55.1 ± 6.4	<0.01

A statistically significant reduction in muscle tone and improvement in motor function were observed.

Electrophysiological Changes

Table 3. Dynamics of EMG parameters of target muscles

Parameter	Before treatment	After treatment
Amplitude of pathological activity	Increased	Reduced
Frequency of spontaneous discharges	High	Moderate
Muscle co-activation	Pronounced	Decreased

Discussion

Structural and Functional Muscle Remodeling

The obtained results demonstrate that botulinum therapy reduces chronic pathological muscle activity, leading to restoration of physiological conditions for muscle stretching, growth, and functional adaptation. Decreased co-activation of antagonist muscles contributes to the formation of more energy-efficient motor patterns.

Physiological Mechanisms

Reduced acetylcholine release at the neuromuscular junction results in a temporary decrease in motor unit activity. Subsequently, compensatory mechanisms are activated, including remodeling of motor units and changes in contractile properties of skeletal muscle.

Conclusions

1. Botulinum therapy induces pronounced structural and functional remodeling of skeletal muscle in children with cerebral palsy.
2. Changes in EMG parameters objectively reflect a reduction in pathological muscle activity.
3. Functional improvement is accompanied by restoration of more physiological motor patterns.
4. Treatment effectiveness depends on baseline spasticity severity and motor impairment level.
5. Botulinum therapy represents an essential component of comprehensive rehabilitation programs.

Scientific Novelty and Practical Significance

The scientific novelty of the study lies in the comprehensive clinical and physiological evaluation of skeletal muscle remodeling after botulinum therapy in children with cerebral palsy, using electromyographic methods as objective tools for assessing muscle adaptation.

The practical significance is determined by the possibility of applying the obtained data to optimize target muscle selection, botulinum toxin dosing, and the development of individualized rehabilitation programs.

Study Limitations

The study is limited by a relatively small sample size and the absence of direct morphological analysis of muscle tissue, highlighting the need for further multicenter studies.

Conflict of Interest

The authors declare no conflict of interest.

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