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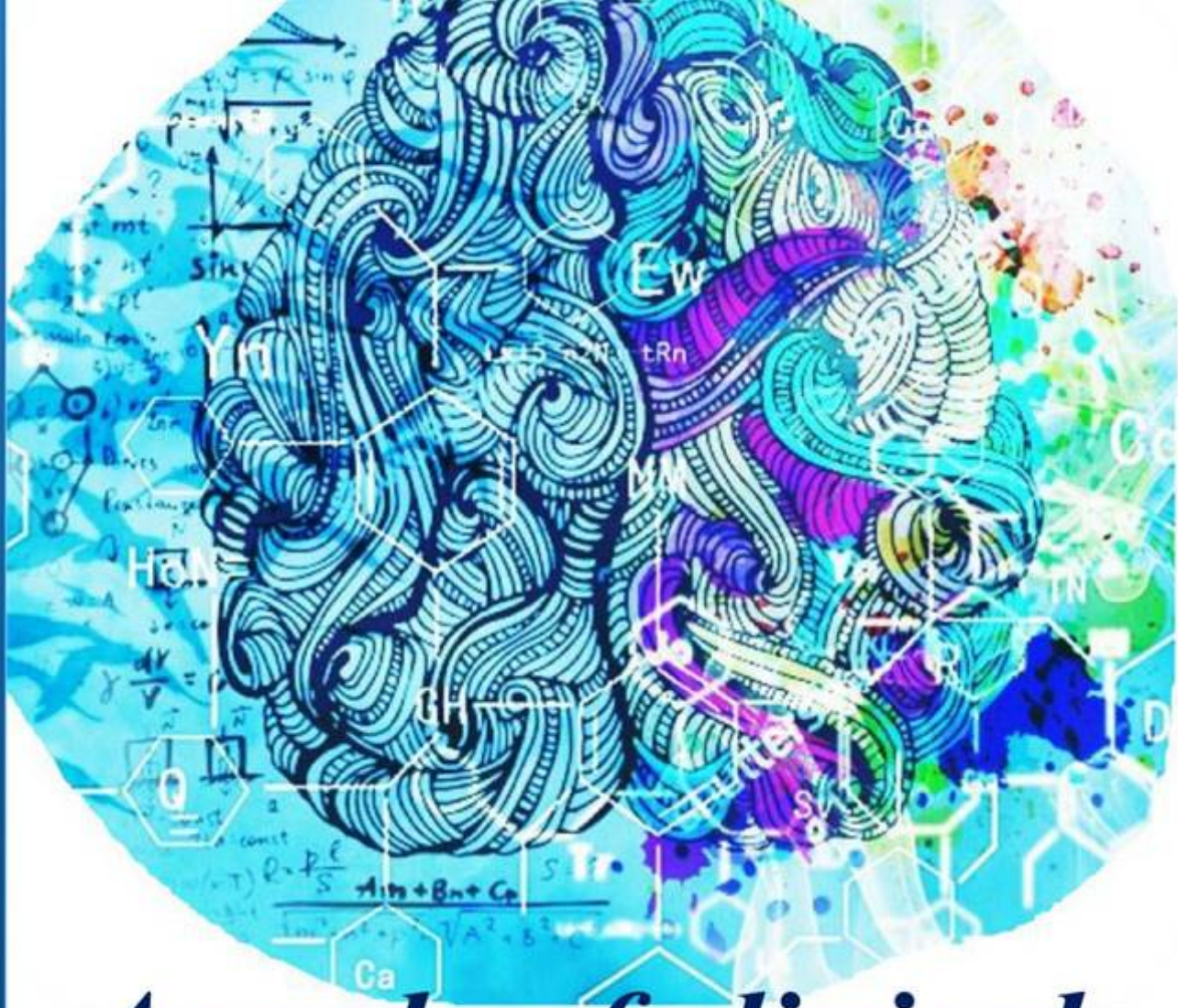

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EVALUATION OF THE EFFECTIVENESS OF A MECHANICAL REHABILITATION GLOVE IN SCHOOL-AGED PATIENTS WITH CEREBRAL PALSY IN THE ANDIJAN REGION

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ANNOTATION

The study titled “Evaluation of the Effectiveness of a Mechanical Rehabilitation Glove in School-Aged Patients with Cerebral Palsy in the Andijan Region” aims to assess the impact of innovative mechanical rehabilitation technology on the motor recovery of children with cerebral palsy (CP). The research involved school-aged patients undergoing comprehensive rehabilitation programs that included the use of a specially designed mechanical glove to improve upper limb motor function. Functional assessments were conducted before and after the intervention to evaluate improvements in muscle tone, fine motor coordination, and range of motion. The results demonstrated that the inclusion of the mechanical glove in rehabilitation therapy significantly enhanced hand functionality, increased patient engagement, and accelerated the recovery of motor skills compared to conventional physiotherapy alone. These findings suggest that mechanical rehabilitation devices can serve as effective adjunct tools in pediatric neurorehabilitation, contributing to better outcomes and quality of life for children with cerebral palsy in regional healthcare settings.

Keywords: cerebral palsy, mechanical rehabilitation glove, occupational therapy, spasticity, up.

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ОЦЕНКА ЭФФЕКТИВНОСТИ МЕХАНИЧЕСКОЙ РЕАБИЛИТАЦИОННОЙ ПЕРЧАТКИ У ШКОЛЬНИКОВ С ДЕТСКИМ ЦЕРЕБРАЛЬНЫМ ПАРАЛИЧОМ В АНДИЖАНСКОМ РЕГИОНЕ

АННОТАЦИЯ

Исследование под названием «Оценка эффективности механической реабилитационной перчатки у школьников с детским церебральным параличом в Андижанском регионе» направлено на изучение влияния инновационных механических технологий реабилитации на восстановление двигательных функций у детей с детским церебральным параличом (ДЦП). В исследовании участвовали пациенты школьного возраста, проходившие комплексную программу реабилитации, включающую использование специально разработанной механической перчатки для улучшения функции верхних конечностей. Функциональная оценка проводилась до и после вмешательства для определения улучшений мышечного тонуса, мелкой моторики и амплитуды движений. Результаты показали, что включение механической перчатки в курс реабилитационной терапии значительно повышает функциональные возможности кисти, увеличивает вовлечённость пациентов и ускоряет восстановление моторных навыков по сравнению с традиционной физиотерапией. Полученные данные свидетельствуют о том, что механические реабилитационные устройства могут служить эффективным дополнительным инструментом в педиатрической нейрореабилитации, способствуя улучшению результатов лечения и качества жизни детей с ДЦП в условиях региональных медицинских учреждений.

Ключевые слова: детский церебральный паралич, механическая реабилитационная перчатка, эрготерапия, спастичность, верхняя конечность.

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АНДИЖОН ВИЛОЯТИДА МАКТАБ ЁШИДАГИ БОЛАЛАРДА МЕХАНИК РЕАБИЛИТАЦИЯ ҚЎЛҚОПИНИНГ САМАРАДОРЛИГИНИ БАҲОЛАШ

АННОТАЦИЯ

«Андижон вилоятида мактаб ёшидаги болаларда болалар церебрал фалажи (БЦФ) билан оғриган беморларда механик реабилитация қўлқопининг самарадорлигини баҳолаш» мавзусидаги тадқиқот инновацион механик реабилитация технологияларининг болалардаги ҳаракат функцияларини тиклашга таъсирини ўрганишга қаратилган. Тадқиқотда мактаб ёшидаги беморлар иштирок этиб, улар комплекс реабилитация дастури доирасида махсус ишлаб чиқилган механик қўлқоп ёрдамида қўлнинг юқори қисми функциясини яхшилашга йўналтирилган машғулотларни бажаришди. Интервенциядан олдин ва кейин функционал баҳолаш ўтказилиб, мушак тонуси, майда моторика ва ҳаракат амплитудасининг яхшиланиши аниқланди. Олинган натижалар шуни кўрсатдики, механик реабилитация қўлқопини терапия жараёнига қўшиш қўл функцияларини сезиларли даражада яхшилайди, беморларнинг фаол иштирокини оширади ва анъанавий физиотерапияга нисбатан мотор кўникмаларнинг тикланишини тезлаштиради. Тадқиқот натижаларига кўра, механик реабилитация воситалари педиатрик нейрореабилитацияда самарали қўшимча усул сифатида қўлланилиши мумкин бўлиб, БЦФ билан оғриган болаларда реабилитация натижаларини ва ҳаёт сифатини яхшилашга ёрдам беради.

Калит сўзлар: болалар церебрал фалажи, механик реабилитация қўлқопи, эрготерапия, спастиклик, юқори қўл.

Introduction. Cerebral palsy (CP) remains one of the leading causes of disability in childhood, with a prevalence of 2-3 cases per 1000 live births [1]. Impaired upper limb function is observed in 50-80% of patients with CP, significantly limiting their daily activities and quality of

life [2]. According to Arner et al., spasticity of the hand and forearm muscles leads to the development of abnormal movement patterns, contractures, and significantly impedes the development of fine motor skills [2].per limbs, school-aged children.

Traditional rehabilitation methods, including massage, exercise therapy, and physiotherapy, often demonstrate limited effectiveness in spastic forms of cerebral palsy [3]. A systematic review by Novak et al. (2013) found that classical approaches provide only a 10-15% improvement in upper limb function [4].

In recent years, robotic rehabilitation technologies have been rapidly developing, with mechanical rehabilitation gloves occupying a special place [5]. Basteris et al. note that these devices allow for precise load distribution, multiple repetitions of movements, and objective monitoring of therapy progress [5]. Krebs and Volpe emphasize the advantages of robotic therapy in the standardization of protocols and the possibility of long-term, intensive training [6].

However, data on the effectiveness of mechanical gloves in children with cerebral palsy remains limited. Given the specific nature of rehabilitation care in the region, exploring the feasibility of introducing modern robotic technologies into children's rehabilitation centers in Uzbekistan is relevant.

Purpose of the study. To evaluate the effectiveness of using a pneumatic rehabilitation glove in the complex therapy of upper limb dysfunction in school-age children with cerebral palsy in the Andijan region.

Material and methods. The study included 30 children aged 7 to 17 years (mean age 11.2 ± 3.1 years) diagnosed with spastic cerebral palsy who were undergoing rehabilitation at medical institutions in the Andijan region from 2023 to 2024.

Inclusion criteria:

1. Spasticity of the wrist flexor muscles of 2-3 points on the modified Ashworth scale [7]
2. Level II-III on the GMFCS scale [8]
3. Preserved cognitive functions allowing them to follow instructions
4. Absence of fixed contractures greater than 30 degrees

Patients were divided into three age groups: 7-10 years (n=7), 11-14 years (n=15), and 15-17 years (n=8).

A programmable pneumatic rehabilitation glove was used in the study. The device consisted of a textile base with integrated pneumatic actuators for each finger. The technical specifications corresponded to those described by Polygerinos et al. [9]:

1. Range of motion: 0-90 degrees at the metacarpophalangeal and interphalangeal joints
2. Adjustable speed: 0.1-2 Hz
3. Biofeedback system with pressure sensors
4. Programmable operating modes (Figure 1).

The rehabilitation course lasted 12 weeks, with sessions scheduled five times per week. Each session lasted 45 minutes, including a preparatory phase (10 minutes); the main part (30 minutes); and a final phase with relaxation exercises (5 minutes).

Therapy was conducted in four modes:

1. Passive mode (first 2 weeks) – cyclic flexion-extension movements with a frequency of 0.5-1 Hz and an amplitude of 30-80% of normal.

2. Active-assistive mode – the patient initiated the movement, and the device provided graduated assistance based on sensor data [10].

3. Resistance mode – for patients with minimal spasticity, it provided graduated resistance of 10-50% of maximum effort.

4. Game mode – completing game tasks on a screen to increase motivation [11].

Figure 1. Pneumatic rehabilitation glove.

Treatment effectiveness was assessed before and after 12 weeks using the QUEST (Quality of Upper Extremity Skills Test) scale, a standardized test for assessing the quality of upper extremity movements, including four domains: dissociative movements, grasping functions, protective extensions, and weight support. Efficacy was also assessed using isometric dynamometry, measuring maximum handgrip strength (N), pinch grip strength (N), endurance (% of maximum strength after 30 seconds), and rate of force development (N/s).

Results. Use of the mechanical glove resulted in statistically significant improvements in all domains of upper limb function (Table 1).

Table 1

Dynamics of functional indicators according to the QUEST scale (n=30)

Assessment domen	**Before treatment**	**After treatment**	**Improvement (%)**	**p-value**
Dissociative movements	22,4±6,8	28,9±7,2	+29,0	<0,01
Gripfunctions	20,1±7,4	27,6±8,1	+37,3	<0,01
Protective extensions	6,2±2,9	8,7±3,1	+40,3	<0,01
Weight support	8,5±3,6	11,8±4,2	+38,8	<0,01

The greatest improvements were noted in the "Protective Extensions" (+40.3%) and "Weight Support" (+38.8%) domains. In the "Dissociative Movements" domain, improvements in isolated finger extension were observed in 24 patients (80%), and in forearm supination in 21 patients (70%). Grasping functions improved significantly: cylindrical grip increased from 43.3% to 83.3% of patients, and pinch grip from 36.7% to 66.7%.

Analysis of isometric dynamometry parameters revealed significant improvements in all hand strength parameters (Table 2).

Table 2

Dynamics of isometric dynamometry parameters (n=30)

Parametr	**Before treatment**	**After treatment**	**Absolute increase**	**Relative difference(%)**	**p-value**
Maximum handgrip strength(H)	89,7±28,4	126,8±32,6	+37,1	+41,4	<0,01

Pinch grip strength (H)	18,3±7,1	27,9±8,8	+9,6	+52,5	<0,01
Endurance (% after 30 sec)	45,2±15,8	61,7±17,2	+16,5	+36,5	<0,01
Rate of force development(H/s)	62,4±19,7	91,3±23,4	+28,9	+46,3	<0,01

Maximum handgrip strength increased by 41.4% ($p<0.01$), reaching 126.8 N, which is close to the lower limit of the age-appropriate norm [12]. The greatest relative improvement was seen in pinch grip strength (+52.5%), which is associated with targeted training of thumb opposition.

Analysis of efficacy across different age groups revealed an inverse relationship with patient age (Table 3).

Table 3

Therapy Effectiveness in Different Age Groups

Age group	**n**	**QUEST improvement (%)**	**Grip strength increase(%)**
7-10 лет	7	+44,8	+48,2
11-14 лет	15	+33,7	+41,5
15-17 лет	8	+28,0	+35,1

The younger age group (7-10 years) demonstrated the best results: a 44.8% improvement in QUEST and a 48.2% increase in strength. In the middle group (11-14 years), the figures were 33.7% and 41.5%, respectively. The older group (15-17 years) showed the smallest, but still significant, effect: 28.0% and 35.1%.

Discussion. The obtained results demonstrate the high efficacy of the pneumatic rehabilitation glove in treating upper limb motor impairments in children with cerebral palsy. The combination of improved movement quality on the QUEST scale and an objective increase in strength indicators confirms the comprehensive positive impact of the technique.

The greatest improvement in the "Protective Extensions" and "Weight Support" domains is explained by targeted training of the wrist and finger extensors, which are typically weakened in children with cerebral palsy due to predominant flexor spasticity [12]. Gracies notes that an imbalance between flexors and extensors is a key factor in functional limitations in spastic paresis [12].

The significant increase in pinch grip strength (52.5%) is of particular practical importance. According to Taylor et al., thumb opposition accounts for up to 50% of hand function [13]. Improving this parameter is critical for performing precise manipulations and daily activities.

The 36.5% improvement in endurance indicates positive changes not only in neuromuscular control but also in muscle metabolic processes. Lieber et al. demonstrated that regular cyclic exercise improves muscle oxidative capacity and increases the number of slow-twitch muscle fibers in patients with spasticity [14].

The 46.3% increase in the rate of force development reflects improved neuromuscular coordination, which is consistent with Elder et al.'s data on impaired temporal characteristics of muscle activation in cerebral palsy [15]. Colombo et al. also emphasize the importance of this parameter for functional activity [10].

Age differences in treatment efficacy support the concept of critical periods of neuroplasticity. Eyre demonstrated that high plasticity of the corticospinal tract is maintained between the ages of 7 and 10 years, resulting in a better response to intensive therapy [16]. Our results (44.8% improvement in the younger group versus 28.0% in the older group) are fully consistent with these data.

Comparison with international studies shows comparable or superior results. Chen and Howard, in a systematic review of robotic therapy in children with cerebral palsy, reported a 25-30% improvement in function [17], while in our study, the average improvement was 36.1%.

A significant advantage of the method used is the ability to conduct long-term, intensive training sessions without tiring the therapist, which is especially important in regions with a shortage of qualified specialists. The game-based approach described by Lohse et al. significantly increased children's motivation and therapy adherence [11].

Conclusion. The use of a pneumatic rehabilitation glove in the comprehensive treatment of school-aged children with cerebral palsy demonstrates high effectiveness in improving upper limb function. The technique provides significant improvements in both qualitative movement characteristics (based on the QUEST scale) and quantitative strength indicators. The greatest effectiveness is observed in the younger age group, emphasizing the importance of early initiation of intensive rehabilitation. The obtained results support the feasibility of introducing robotic technologies into children's rehabilitation centers in Uzbekistan.

1. The use of a mechanical rehabilitation glove in children with cerebral palsy improves upper limb functional performance by 29.0-40.3% across various domains of the QUEST scale.

2. Therapy results in an increase in maximum handgrip strength by 41.4%, pinch grip strength by 52.5%, endurance by 36.5%, and the rate of force development by 46.3%.

3. The effectiveness of the technique depends on the patient's age: the best results are achieved in the 7-10 year old group (44.8% improvement), due to high neuroplasticity.

4. The mechanical rehabilitation glove can be recommended as an effective component of comprehensive rehabilitation for school-aged children with cerebral palsy.

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АННАЛЫ КЛИНИЧЕСКИХ ДИСЦИПЛИН

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