Effect of Professor Kozyavkin method on hand function in children with cerebral palsy

Abstract. Background. Impaired hand function is one of the key factors that restrict the ability of patients with cerebral palsy (CP) to perform everyday activities and self-care. Recent studies show effectiveness of intensive multicomponent methods of rehabilitation for improving hand function in children with CP. One of such methods is Intensive Neurophysiological Rehabilitation System, also known as Professor Kozyavkin method, a multicomponent system that combines various interventions into one intensive course. The aim of this study was to assess changes in hand function in children with CP after the two-week rehabilitation course by Kozyavkin method. Materials and methods. Thirty-two patients with bilateral spastic CP (aged 6–15 years, Manual Ability Classification System level I–III) have participated in the study. All patients underwent the two-week rehabilitation course by Kozyavkin method. Treatment lasted up to 5 hours per day and included physical therapy, occupational therapy, spinal manipulative technique, reflexotherapy, joint mobilization, computer game therapy, and other interventions. The primary outcome measure was Jebsen-Taylor hand function test and the secondary outcome measures were ABILHAND-Kids questionnaire, Box and Blocks test, and hand dynamometry. Results. Statistically significant improvement by 14.9 ± 38.0 seconds was observed during Jebsen-Taylor test for the dominant hand. Changes in Box and Blocks test were also statistically significant and were equal to 2.0 ± 3.7 points for dominant hand and 1.8 ± 2.8 points for non-dominant hand. Grip strength did not change; increase in ABILHAND-Kids score was not statistically significant. Conclusions. Hand function, particularly dexterity of both hands and unimanual functions of the dominant hand, had improved in children with cerebral palsy after the two-week treatment course by Kozyavkin method. Keywords: cerebral palsy; motor disorders; rehabilitation; hand; activities of daily living

Introduction
Hand function, the ability of the hands to perform properly in different contexts, is often restricted in children with cerebral palsy (CP) [1]. According to recent studies, 50–60 % of patients with CP suffer from upper limb impairments that considerably vary and include the fine motor deficit, decreased manual dexterity and weak grip strength [2–4]. Children with CP experience difficulties with pointing, reaching, grasping, manipulating, releasing and throwing objects. Consequently, children experience limitations in activities of daily life and participation restrictions [5].

There are many treatment programs aimed at improving hand function in children with CP [6–8]. Most promising results are shown in the studies of intensive, goal-oriented, high-dose, repetitive, incrementally challenging, functional interventions, such as a constraint-induced movement therapy and hand-arm bimanual intensive therapy [9, 10]. The common advantage of these interventions is the possibility to work through not only Body functions and Body structures domains but also Activity and Participation domains of the International Classification of Functioning, Disability and Health (ICF) [11]. So, the attention of both researchers and clinicians is focused on the exploration of intensive, goal- and function-oriented treatments addressing multiple limitations in children with CP.
One of such interventions is the Intensive Neurophysiological Rehabilitation System (INRS), also known as Kozyavkin method [12]. It combines different active and passive modalities within a two-week treatment course and is aimed at different functional goals within the ICF model [11]. The latest research demonstrated improvement in gross motor functions and a decrease of muscle spasticity in children with CP undergoing treatment with INRS [13, 14]. Improvement of the hand functions is also one of the most important targets of the INRS. Retrospective analysis of medical records of CP children reveals the improvement of fine motor function in 32 % of the whole group of patients [15].

Therefore, the aim of this pilot pre-post study is to assess changes of hand function in children with bilateral spastic cerebral palsy after the two-week intensive course using INRS.

Materials and methods

Study design

Single-arm, pre-post study design was used. Assessments were performed before and after a two-week treatment course by INRS, with patients serving as their own controls. The same evaluator assessed each child both times; evaluators were not involved in the study in another way. The study protocol was reviewed and approved by the local Ethical Commission of the International Rehabilitation Clinic (protocol number N-2018-02-12). Participants and their legal representatives received comprehensive information about the intervention and study design; written informed consent was obtained from legal representatives. Verbal consent was given by participants, when appropriate, based on age and cognitive skills. This pilot study was registered at clinicaltrials.gov with identifier NCT03454412.

Participants

All participants were patients of the International Rehabilitation Clinic. Eligibility criteria were: age 6 to 15 years, spastic forms of CP, bilateral impairment, level I–III according to the Manual Ability Classification System (MACS). Exclusion criteria were: severe epileptic syndrome, moderate to severe mental deficiency, inability to understand and comply with instructions, uncooperative behavior, severe contractures of upper extremity joints, and previous hand surgery. Forty-four patients were recruited. After applying the exclusion criteria, 32 patients were selected for the study. The demographic and clinical characteristics of the participants are presented in Table 1. The average age of the children was 10.2 years (SD = 2.9). Among them, 56.3 % were males, 56.3 % have a dominant right hand, 65.6 % were children with spastic quadriplegia, GMFCS level III was found in 40.6 % of patients, and MACS level II — in 46.8 %. The hand dominance in participants was established using the parental report and medical history.

Intervention

All patients underwent a two-week rehabilitation course by INRS, also known as the Professor Kozyavkin method. INRS is a novel multicomponent rehabilitation approach that combines versatile interventions into one intensive course [12]. The goal of INRS is to improve the functioning and quality of life of children with CP.

Treatment components are addressing different functional goals in the Body functions (joint mobility, muscle tone, voluntary movement, pain) and Activities and Participation (fine hand use, walking, moving around, interpersonal interactions and family relationships) domains of the ICF [11, 16]. The INRS course includes four to five hours of daily training, five days per week, for two weeks. Treatment is child-friendly and intensive at the same time. Interventions are aimed at improving different functions, influencing various pathogenic pathways and reaching the bigger total effect by potentiating each other. Treatment includes age-appropriate, goal-oriented tasks with consecutively increased difficulty. Unimanual and bimanual activities for training fine and gross motor functions are delivered in a child-friendly way with elements of play.

The individual treatment program is developed taking into account patient’s goals and condition, indications and contraindications. It may include the following components: physical therapy, occupational therapy, spinal manipulative technique, reflexotherapy, joint mobilization, computer game therapy, special massage

### Table 1. Demographic and clinical characteristics of patients, n (%)*

| Characteristic | Participants (n = 32) |
|---------------|----------------------|
| **Age (years)** |                      |
| Mean (SD)     | 10.2 (2.9)           |
| **Gender**    |                      |
| Male          | 18 (56.3)            |
| Female        | 14 (43.7)            |
| **Dominant hand** |                   |
| Right         | 18 (56.3)            |
| Left          | 14 (43.7)            |
| **Diagnosis** |                      |
| CP, spastic diplegia | 11 (34.3) |
| CP, spastic quadriplegia | 21 (65.6) |
| **MACS level** |                    |
| I             | 7 (21.9)             |
| II            | 15 (46.8)            |
| III           | 10 (31.3)            |
| **GMFCS level** |                 |
| I             | 8 (25.0)             |
| II            | 10 (31.3)            |
| III           | 13 (40.6)            |
| IV            | 1 (3.1)              |

Notes: * — unless mentioned otherwise; SD — standard deviation.
system, strength training, physical exercises with move-
ment correction suit, treadmill training for gait correc-
tion, vibration therapy, and group sessions of rhythmic
gymnastics.

Physical therapy is performed daily and includes indi-
vidualized exercises aimed at gross motor function training.
It helps strengthen the muscles and improve the functional
mobility of upper and lower extremities. Occupational the-
rapy is focused on the development of skills necessary for the
performance of everyday activities including play and self-
care activities such as dressing, grooming and feeding, and
fine motor tasks such as writing and drawing. The treatment
program includes both unimanual and bimanual tasks. Full
body massage incorporates classic, deep tissue, perioseal
massage, trigger point therapy and muscle stretching tech-
niques. Spinal manipulative therapy is used in a variation
called “biomechanical correction of the spine”, in which the
special high-speed, low-amplitude thrusts techniques are
used in lumbar, thoracic and cervical regions. Joint mobiliz-
goals are to increase range of motion, decrease pain and
improve the function of the extremities. During paraffin
and wax applications, different muscle groups and joints are
enveloped in warm paraffin and wax wraps. Reflexotherapy
is a cutaneous electrical stimulation of acupuncture points
with the use of the special low-current portable device.
Strength training, or mechanotherapy, is aimed at building
up muscle strength and endurance using various equipment
and assistive technologies for resistance. Children play re-
habilitation computer games, developed specifically for pa-
tients with movement disorders, using different game con-
soles and equipment (Nintendo Wii Fit with the balance
board, Xbox with the Kinect motion sensor, Dance Mat)
[17]. During movement correction suit therapy, physical
exercises are performed using a special “Spiral” suit that
provides extra loading on the trunk and extremities. It helps
patients to correct movements and posture and attain new
movement patterns [18]. Vibration therapy utilizes high-
frequency, low-magnitude vibration to promote bone and
muscle strength. Treadmill training is aimed at gait cor-
tection. Group session of rhythmic gymnastics includes
dancing and performing exercises with the use of music in
small groups of peers. A detailed description of the treat-
ment system including indications and contraindications
is presented in the rehabilitation manual of the Professor
Kozyavkin method [12].

Outcome measures

The primary outcome measure was the Jebsen–Taylor
hand function test (JTHFT). It evaluates fine and gross
motor hand function using tasks that simulate activities of
daily living [19]. The JTHFT consists of 7 items: writing a
short sentence, turning over a card, picking up small com-
mon objects, simulated feeding using a teaspoon, stack-
ing four checkers, moving large light cans and then large
heavy cans. Administration guidelines specify that testing
begins with the non-dominant hand. The writing task was
excluded from the assessment due to the age of some chil-
dren. Each item is scored according to the time taken to
complete the task; time is rounded to the nearest second.
The scores for all 6 items are then summed for a total score
for each hand.

The secondary outcome measures were ABILHAND-
Kids questionnaire, Box and Blocks test (BBT), and hand-
grip dynamometry.

Manual dexterity is evaluated using BBT, a valid and reli-
able test [20]. The task is to carry wooden blocks from one
compartment to another above the partition by one hand;
only one block at a time is allowed to be transported. The
score is the number of blocks carried in one minute.

Both JTHFT and BBT showed good reproducibility and
responsiveness in children with CP. A recent study con-
firmed the reliability of the tests when the assessments were
performed within two weeks and the responsiveness during
intensive interventions [21].

ABILHAND-Kids is a measure of manual ability for
children with upper limb impairments [22]. The parents were
asked to fill in the Ukrainian version of the questionnaire by
estimating their child’s performance of 20 unimanual and
bimanual activities on a 3-level scale (impossible, difficult,
easy) [23]. A total score is calculated and presented in the
logits (the linear measure that expresses the odds of success
of the patient in performing tasks) and the percentage of his/
her performance.

Grip strength was quantified using Jamar hand dynamo-
meter (Performance Health, USA). It displays results in
kilograms. All children had three trials for each hand and the
best result was saved.

Statistical analysis

Data analysis was performed using IBM SPSS v23
software. The normality of distribution was evaluated
using the Kolmogorov-Smirnov test. Pre- and post-in-
tervention values were compared using the paired sample
t-tests.

Results

The parametric statistics was used to describe the data.
Mean values at baseline and post-intervention assessment
are summarized in Table 2 and Fig. 1.

Table 3 shows changes in the primary outcome mea-
sure — Jebsen–Taylor test and its subtests. An asterisk in-
dicates a statistically significant difference where 2-tailed
p-values are less than or equal to 0.05.

Jebsen–Taylor hand function test was the primary outcome
measure in this study. Both hands were assessed separately.
JTHFT total score for the dominant hand decreased by 14.9
seconds (SD = 38), from 130.1 to 115.2, after the treatment
course using INRS in the whole group. The paired sample
t-test showed that this change was statistically significant
(p < 0.05). Non-dominant hand total score changed by 10.1
seconds (SD = 38), from 130.1 to 115.2, after the treatment
using the Kolmogorov-Smirnov test. Pre- and post-in-
tervention values were compared using the paired sample
t-tests.

We observed statistically significant improvement in the
results of lifting light objects by non-dominant hand (1.2,
SD = 3.2, p < 0.05), simulated feeding by dominant hand
(10, SD = 26.4, p < 0.05), lifting light objects by dominant
hand (0.8, SD = 1.9, p < 0.05) and lifting heavy objects by
dominant hand (1.9, SD = 2, p < 0.05).
Box and Blocks test was the secondary outcome measure aimed at assessing the dexterity of each hand separately. We noted meaningful changes in BBT results for both hands. For the dominant hand, the score improved by 2 blocks (SD 3.7, p < 0.05) and for non-dominant — by 1.8 blocks (SD 2.8, p < 0.001).

ABILHAND-Kids questionnaire also was a secondary outcome measure. The goal of this scale is to evaluate the hand function of the child in everyday life tasks. It includes both unimanual and bimanual tasks, they are not scored up separately, so this measure is not split by hands. ABILHAND-Kids score increased by 0.34 (0.98) logits, from 1.92 to 2.26, which was close to the statistically significant value (p = 0.06).

Hand dynamometry was the secondary outcome measure aimed at assessing the strength of hand grip. Changes of the grip strength of 0.24 kg for the dominant hand and 0.32 kg for non-dominant hand were not significant.

**Table 2. Baseline and post-intervention results**

| Outcome measure               | Baseline, mean (SD) | Post-intervention, mean (SD) | Difference, mean (SD) | Sign. (2-tailed)/ p-values |
|-------------------------------|---------------------|------------------------------|-----------------------|---------------------------|
| ABILHAND-Kids (logits)        | 1.92 (1.8)          | 2.26 (2.0)                   | –0.34 (0.98)          | 0.06                      |
| **Dominant hand**             |                     |                              |                       |                           |
| Jebsen-Taylor test (total score) | 130.1 (83)         | 115.2 (77)                   | 14.9 (38)             | 0.035                     |
| Box & Blocks test             | 33.5 (12)           | 35.5 (13)                    | 2.0 (3.7)             | 0.04                      |
| Hand-grip dynamometry         | 12.1 (5.6)          | 11.8 (5.4)                   | 0.24 (2.3)            | 0.56                      |
| **Non-dominant hand**         |                     |                              |                       |                           |
| Jebsen-Taylor test (total score) | 191.5 (109)        | 181.4 (114)                  | 10.1 (49)             | 0.260                     |
| Box & Blocks test             | 28.0 (11)           | 29.8 (11)                    | 1.78 (2.8)            | 0.001                     |
| Hand-grip dynamometry         | 10.8 (6.0)          | 10.5 (4.9)                   | 0.32 (1.9)            | 0.34                      |
**Discussion**

The aim of this exploratory study was to assess the effect of the Kozyavkin method on hand function in children with cerebral palsy. We used JTHFT as a primary outcome measure and ABILHAND-Kids, BBT and hand-grip dynamometry as the secondary outcome measures.

We noted statistically significant improvements in the results of Jebsen-Taylor hand function test for dominant hand along with some of its components for both hands and Box and Blocks test for both hands.

**JTHFT**

The observed change of 14.9 seconds in total JTHFT score for the dominant hand was statistically significant. A decrease in JTHFT score means improvement of the hand function. To evaluate clinical significance of this change, we compared it with the smallest real difference (SRD) of 5.09 seconds for the total score of the dominant hand, measured in a sample of typically developed children [24]. The SRD is the smallest change in score between assessments that represents a true change over and above measurement error. We used the aforementioned SRD value for assessment since neither SRD for CP children nor minimal clinically important difference (MCID) is established for JTHFT. So, the detected difference of 14.9 seconds was greater than SRD. We can interpret this finding as clinically meaningful improvement of the dominant hand function after treatment by INRS.

We also observed statistically significant improvement in the results of the following JTHFT subtests: simulated feeding by dominant hand, lifting light objects by dominant hand, lifting heavy objects by dominant hand, and lifting light objects by non-dominant hand. A possible explanation of these findings may be that improved subtasks need similar types of movements and involvement of the same motor skills. Lifting and moving light and heavy large objects are actions that need more gross than fine motor skills and do not require precise fine manipulation to be completed. Simulated feeding is a task that needs a combination of the pincer grasp with gross manipulation but still can be accomplished without precise and coordinated use of fingers. These observations are in line with previous research concluding that treatment by INRS improves gross motor functions in children with CP [14].

**Box and Blocks Test**

We noted meaningful changes in BBT results for both hands: by 2 blocks per minute for dominant and by 1.8 blocks — for non-dominant. Higher BBT scores mean that manual dexterity has improved after the treatment. Since MCID is not established for BBT in children with CP, we have calculated it as a half of the standard deviation of the changes [25]. The result is considered clinically significant when the observed change is bigger than MCID. Improvements of both dominant and non-dominant hands were higher than calculated MCID values of 1.85 and 1.4, respectively. So, clinically meaningful improvement in manual dexterity of children with CP was noted after the course with INRS.

**ABILHAND-Kids**

ABILHAND-Kids improvement of 0.34 logits was close to statistically significant (p = 0.06). A possible explanation why positive changes didn’t reach significance level might...
be that the period between observations was short — only two weeks. Therefore, parents who filled in the questionnaire need some time to distinguish changes in their child’s abilities, and children need the time before they will start practice daily activities that were impossible or hard for them to accomplish earlier.

**Hand dynamometry**

We did not observe changes in grip strength after the treatment. But the study of other intensive rehabilitation techniques also did not show improvement of muscle strength while hand function and dexterity improved [26].

Our findings are in line with the result of the latest research showed that intensive functional trainings can improve hand function in children with CP [27, 28]. Previous studies also showed that other high-intensity programs, combined of interventions for both upper and lower limbs and delivered during the short period of time, were effective for improving hand function in children with unilateral and bilateral spastic CP [29, 30].

INRS comprises all features that proved to be important for upper limb training to be successful — high intensity, relevance of training to daily life, the correspondence of training to the age and goals of the child [31]. One of the possible mechanisms of action of this short-term intense treatment is that interventions merged into the course with INRS are aimed at improving different functions, influencing various pathogenic pathways, and reaching the bigger total effect by potentiating each other.

**Limitations**

One of the limitations of our study is its short-term nature that makes it impossible to access long-term results. Another limitation is a lack of blinding due to the pre-post design with the absence of the control group. Another possible restraint is a relatively small sample size.

Currently, our team is conducting a double-blind randomized control trial with larger sample size and longer follow-up period to address all limitations of the present study and achieve more conclusive evidence. It was registered on clinicaltrials.gov under the identifier NCT04093180.

**Conclusion**

Hand function, particularly dexterity of both hands and unimanual functions of the dominant hand, had improved in children with cerebral palsy after the two-week treatment course by Kozyavkin method. Randomized controlled trials are needed for further investigation of this treatment system.

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**Conflicts of interests.** Authors declare the absence of any conflicts of interests and their own financial interest that might be construed to influence the results or interpretation of their manuscript.

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Вплив методу професора Козякіна на функцію рук в дітей із церебральним параліччю

Резюме. Актуальності. Порушення функції рук є одним із факторів, що найбільш обмежують самобутність та функціонування в повсякденній діяльності. Метою дослідження було вивчити вплив методу Козякіна на функцію рук у дітей із церебральним паралічом. Описаний метод включає в себе процедуру у ряді фаз із використанням інтенсивних тренувань. Дослідження здійснювалися на дітях віком від 6 до 15 років з атипічними формами церебрального паралічу.

Матеріали та методи. У дослідженні брали участь 32 пацієнти, які проходили двотижневий курс реабілітації за методом Козякіна. Дослідження проводилися за підтримки інтренціонерів та професорської команди.

Результати. Після двотижневого курсу реабілітації було виявлено припинення зміни функції рук, але змінисть в майбутньому може відрізнятися в залежності від віку та особистості дітей.

Висновки. У дослідженні було зазначено, що метод Козякіна є ефективним засобом підвищення функції рук в дітей із церебральним паралічом.

Ключові слова: церебральний параліч, моторні порушення, реабілітація.
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Влияние метода профессора Козявкина на функцию руки у детей с церебральным параличом

Резюме. Актуальность. Нарушение функции руки является одним из факторов, которые больше всего ограничивают самообслуживание и выполнение повседневных действий пациентами с церебральным параличом (ЦП). В исследованиях последних лет продемонстрирована эффективность интенсивных многокомпонентных методов реабилитации для улучшения функции руки у детей с ЦП. Одним из таких методов является система интенсивной нейрофизиологической реабилитации, известная также как метод профессора Козявкина, — многокомпонентная система, объединяющая разнородные вмешательства в один интенсивный курс. Целью этого исследования было оценить изменения функции руки у детей с ЦП после двухнедельного курса реабилитации по методу Козявкина.

Материалы и методы. В исследовании принимали участие 32 пациента в возрасте 6–15 лет со спастическими формами ЦП (двуствороннее поражение, I–III уровень по Системе классификации функции руки). Все пациенты проходили двухнедельный курс реабилитации по методу Козявкина. Лечение продолжалось до 5 часов в день и состояло из физической терапии, эрготерапии, биомеханической коррекции позвоночника, рефлексотерапии, мобилизации суставов, компьютерной игротерапии и других лечебных воздействий. Основным инструментом оценки был тест функции руки Джебсена — Тэйлора, а дополнительными — опросник ABILHAND-kids, тест «Кубики в коробке» и динамометрия кисти.

Результаты. Статистически достоверное улучшение на 14,9 ± 38,0 секунды было обнаружено при выполнении теста Джебсена — Тэйлора для доминантной руки. Изменения теста «Кубики в коробке» также были статистически достоверными и составляли 2,0 ± 3,7 пункта для доминантной руки и 1,8 ± 2,8 пункта — для недоминантной. Сила руки не изменилась; увеличение оценки по опроснику ABILHAND-Kids не было статистически достоверным.

Выводы. После двухнедельного курса лечения по методу Козявкина у детей с церебральным параличом улучшились функции руки, в частности ловкость обеих рук и функционирование доминантной руки.

Ключевые слова: церебральный паралич; моторные нарушения; реабилитация; рука; повседневная деятельность

Review of the manuscript

"Effect of the Professor Kozyavkin method on hand function in children with cerebral palsy" submitted to the International Neurological Journal (Ukraine)

The article under the review deals with important issues of upper limb disorders in children with cerebral palsy. Limited hand function is a common and disabling impairment in children with CP and a strong predictor of child's ability to participate in daily activities.

Currently, there are different treatment options for upper limb dysfunction in children with CP. Latest evidence indicates the importance of treatment intensity using goal-oriented, repetitive, incrementally challenging interventions.

The manuscript under the review is presenting the data of the pilot study of the so called Intensive Neurophysiological Rehabilitation System also known by the name of its author as the Kozyavkin method. This treatment system is the intensive approach that combines different treatment modalities aimed at different functional goals within the ICF model. The study is evaluating changes in hand function observed during the two-week course of intensive treatment.

The study design fits well to the requirements of the exploratory type of study. In general, the study was planned well, the sample of 32 children with spastic bilateral cerebral palsy was sufficient for quantification of changes observed in the study group.

In my opinion, the outcome measures selected for the study are appropriate, valid and reliable. They are aimed primarily at the Body function and Activity domains of the ICF. I would suggest the authors to use in the future outcomes evaluating Participation domain as well.

Statistical methods used for the analysis are appropriate and well documented. Manuscript along with statistical significance calculation analysis also includes estimation of the minimal clinically important difference values, evaluating clinical relevance of the obtained results.

Of course, such type of studies has multiple limitations, but they are highlighted correctly by the authors in the Discussion section of the manuscript.

In my opinion, the manuscript could be accepted for publication in International Neurological Journal.

With kind regards,
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