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ORGANISATION OF EARLY INTERVENTION FOR PRETERM INFANTS: EXPERIENCE OF STRUCTURED COORDINATION BETWEEN A FOLLOW-UP CLINIC AND A REHABILITATION DEPARTMENT

ОРГАНІЗАЦІЯ РАННЬОГО ВТРУЧАННЯ ДЛЯ ПЕРЕДЧАСНО НАРОДЖЕНИХ ДІТЕЙ: ДОСВІД СТРУКТУРОВАНОЇ КООРДИНАЦІЇ МІЖ КАТАМНЕСТИЧНИМ КАБІНЕТОМ І РЕАБІЛІТАЦІЙНИМ ВІДДІЛЕННЯМ

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Abstracts

Aim. To evaluate how structured coordination between the follow-up clinic and the rehabilitation department affects the timeliness of referral of preterm infants to the multidisciplinary rehabilitation team (MDRT) and their AIMS and HINE dynamics.

Materials and Methods. A partly retrospective comparison of two cohorts with a historical control group (2023–2026; n = 148; gestational age 24–36 weeks): the intervention group (IG, n = 84, discharged 2024–2025, structured coordination protocol) and the control group (CG, n = 64, discharged 2023, without systematised interaction). All infants underwent the General Movements Assessment (Prechtl) in the NICU and AIMS and HINE assessment. Where delay was identified, an electronic referral to the MDRT was issued and an outpatient course of active function-based rehabilitation (10–14 sessions) with parent training and a home programme was prescribed, without passive neurodevelopmental techniques.

Results. At baseline the groups did not differ in pathological general movements ($p = 0.61$) or HINE score (46.3 ± 5.4 versus 44.8 ± 6.2; $p = 0.12$), but the IG contained more infants born before 28 weeks (29.8 % versus 10.9 %; $p = 0.006$). Timely referral to the MDRT was received by 91.7 % of the IG versus 46.9 % of the CG ($p < 0.001$), and the mean interval from discharge to the first physical therapist appointment was 7.2 ± 1.4 versus 14.6 ± 3.8 weeks ($p < 0.001$). At the 6-month repeat assessment the mean HINE score rose by 12.1 points in the IG (to 58.4 ± 5.1; paired $t = 17.60$; $df = 83$) and by 6.4 in the CG (to 51.2 ± 6.8; paired $t = 9.06$; $df = 63$), remaining in both groups below the 64-point cut-off for preterm infants at this age; the between-group difference was significant ($p < 0.001$). Age-appropriate AIMS scores were reached by 52.4 % versus 31.3 % at 6 months ($p = 0.010$) and 71.4 % versus 45.3 % at 12 months of corrected age ($p = 0.001$). Missed follow-up visits occurred in 11.9 % versus 39.1 % ($p < 0.001$), decreasing to 7.3 % among IG families with high parental compliance; it covers only children who completed the 12-month observation.

Conclusions. In a single centre, structured interdepartmental coordination combined with active function-based rehabilitation and parental involvement was associated with earlier referral and better motor and neurological outcomes. A causal conclusion requires a prospective study with a concurrent control group.

Keywords: preterm infants, follow-up clinic, multidisciplinary rehabilitation team, General Movements Assessment, Alberta Infant Motor Scale, Hammersmith Infant Neurological Examination, active function-based rehabilitation, early intervention, motor development.

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Мета. Оцінити ефективність структурованої координації роботи катамнестичного кабінету та реабілітаційного відділення щодо своєчасності скерування передчасно народжених дітей до МДРК і динаміки AIMS та HINE.

Матеріали та методи. Частково ретроспективне порівняння двох когорт з історичною контрольною групою (2023–2026 рр.; n = 148; ГВ 24–36 тиж.): ОГ (n = 84, 2024–2025 рр., структурований протокол координації) та КГ (n = 64, 2023 р., без систематизованої взаємодії). Усі діти обстежені за GMA (Прехтль) у ВІТН, а також за AIMS та HINE. За виявлення затримки оформлювалося електронне скерування до МДРК, яка формувала ІПР і призначала амбулаторний курс активної функціональної реабілітації (10–14 занять) з навчанням батьків і домашньою програмою, без пасивних нейророзвиткових технік.

Результати. На вихідному рівні групи не відрізнялися за патологічними рухами GMA (p = 0,61) та балом HINE (46,3 ± 5,4 проти 44,8 ± 6,2; p = 0,12), проте в ОГ була вищою частка дітей, народжених до 28 тижнів (29,8 % проти 10,9 %; p = 0,006). Своєчасне скерування до МДРК отримали 91,7 % дітей ОГ проти 46,9 % КГ (p < 0,001); середній термін від виписки до першого прийому фізичного терапевта становив 7,2 ± 1,4 проти 14,6 ± 3,8 тижня (p < 0,001). При повторному оцінюванні у 6 місяців бал HINE зріс на 12,1 бала в ОГ (до 58,4 ± 5,1; парний t = 17,60; df = 83) і на 6,4 бала в КГ (до 51,2 ± 6,8; парний t = 9,06; df = 63), залишаючись в обох групах нижчим за межу 64 бали для цього віку в передчасно народжених дітей; міжгрупова різниця значуща (p < 0,001). Вікових норм AIMS досягли 52,4 % проти 31,3 % у 6 місяців (p = 0,010) і 71,4 % проти 45,3 % у 12 місяців скоригованого віку (p = 0,001). Пропуск планових візитів становив 11,9 % проти 39,1 % (p < 0,001), знижуючись до 7,3 % серед родин ОГ з високим комплаєнсом; показник стосується лише дітей, які завершили 12-місячне спостереження.

Висновки. В умовах одного центру структурована координація між відділеннями у поєднанні з активною функціональною реабілітацією та залученням батьків асоціювалася з більш раннім скеруванням і кращими моторними та неврологічними результатами. Причинний висновок потребує проспективного дослідження з одночасною контрольною групою.

Ключові слова: передчасно народжені діти, катамнестичний кабінет, мультидисциплінарна реабілітаційна команда, GMA (метод Прехтля), AIMS, HINE, активна функціональна реабілітація, раннє втручання, моторний розвиток.

1. Introduction

Preterm birth is one of the leading causes of childhood morbidity and disability. According to WHO estimates, 13.4 million infants were born preterm in 2020, approximately one in ten of all live births [10]. In Ukraine the preterm birth rate is 6–8 %. Among infants with a gestational age below 32 weeks the risk of persistent motor impairment reaches 15–20 %, and the risk of cerebral palsy at a gestational age < 28 weeks is 10–20 % [2]. Early and accurate diagnosis followed by timely rehabilitation is a key condition for optimising neuroplasticity and functional outcome [8].

The immaturity of the central nervous system in preterm infants manifests through several interrelated pathophysiological mechanisms. Cortical neuronal migration and synaptogenesis continue throughout the third trimester and proceed actively after birth. Myelination of nerve fibres begins at 24–28 weeks and is particularly vulnerable to hypoxic-ischaemic and inflammatory injury. The periventricular white matter, a region critical for motor pathways, is the principal target of the injury characteristic of prematurity [18]. For this reason, systems of follow-up observation and early rehabilitative intervention are acquiring increasing clinical and organisational significance.

Prechtl's General Movements Assessment (GMA) is one of the most valid instruments for early neurological evaluation in the neonatal intensive care unit (NICU). The absence of fidgety movements at 3–5 months of corrected age is associated with the risk of cerebral palsy, with sensitivity up to 98 % and specificity up to 95 % [1; 8]. The method is non-invasive, requires no special equipment and can be performed directly in the NICU, which makes it a natural first step in the clinical pathway. Alongside GMA, neuroimaging and clinical examination using standardised scales constitute the contemporary triad of early diagnosis [8].

After discharge from the NICU the infant passes under the supervision of the follow-up clinic. The Department of Follow-Up Observation and Rehabilitation Treatment of Children of the Ivano-Frankivsk Regional Perinatal Centre was opened in 2023. In 2024 the department obtained a licence from the National Health Service of Ukraine for the package of medical services

«Medical rehabilitation of children born preterm and/or ill during the first three years of life». The paediatrician-neonatologist and the neurologist of the follow-up clinic monitor the acquisition of age-appropriate skills and, where delay is detected, issue an electronic referral to the rehabilitation department of the same institution. Referrals are also accepted from other healthcare institutions of Ukraine and from paediatricians or other specialists in cases where follow-up examination has not been performed.

The Alberta Infant Motor Scale (AIMS) is a standardised observational scale of motor development (58 items in 4 positions) normed for corrected age [5]. The Hammersmith Infant Neurological Examination (HINE) is a structured neurological examination whose scorable neurological section comprises 26 items in five subsections – cranial nerve function, posture, movements, tone, and reflexes and reactions – each scored from 0 to 3, giving a maximum global score of 78; it is validated from 2 to 24 months of corrected age and sensitive to change under rehabilitative intervention [15]. Both scales are used in the rehabilitation department for baseline and repeated assessment. Infants born preterm score lower on the HINE than their term-born peers even in the absence of cerebral palsy: in a prospective cohort the mean total score at 3–7 months of corrected age was 61.8 (95 % CI 60.5–63.1) in infants born at 32–36 weeks versus 63.3 (62.6–63.9) in term-born infants appropriate for gestational age, and a score at or below the 10th centile was recorded in 39.5 % versus 10.1 % respectively [12].

The current evidence base for the rehabilitation of preterm infants clearly supports approaches oriented towards the active acquisition of age-appropriate motor skills – so-called active function-based rehabilitation (activity-based/task-oriented intervention) – as opposed to passive neurodevelopmental techniques, whose effectiveness is not confirmed by contemporary research [6; 8]. In a randomised single-blind trial, Ochandorena-Acha et al. [9] found no between-group difference in gross motor development (AIMS) at 2 or 8 months of corrected age after an early physiotherapy programme delivered from the neonatal period to 2 months of corrected age; differences in the fine motor, problem-solving and communication domains were present at 1 month of corrected age but were no longer present at 8 months. The authors attributed the absence of an effect on gross motor development to the limited dose and intensity of the intervention and to poor parental compliance with the home programme. Morgan et al. [6] showed in a randomised controlled trial (the GAME programme) that the combination of active motor learning, goal-oriented tasks and an enriched environment improves motor outcomes in high-risk infants compared with standard care. Horoshko et al. [4] emphasise that the diversity of clinical forms of motor impairment in children requires a differentiated selection of physical therapy methods and their comprehensive combination within an individual programme rather than the application of a uniform intervention. A Cochrane systematic review of early developmental intervention programmes delivered after hospital discharge [11] found that such programmes probably improve motor outcomes in infancy (standardised mean difference 0.12, 95 % CI 0.04 to 0.19) and may improve cognitive outcomes (standardised mean difference 0.27, 95 % CI 0.15 to 0.40); the cognitive advantage persists at preschool age, whereas the motor advantage does not.

The effectiveness of any rehabilitation method depends critically on the timeliness of its initiation. Seppänen et al. [16], drawing on data from 11 European countries, showed that the organisational characteristics of follow-up systems directly determine the coverage of children by services: where programmes are formally regulated, the proportion of children under supervision at 5 years reached 42.1–70.1 %, compared with less than 20 % in countries without corresponding recommendations. The position statement of the Canadian Paediatric Society [3] likewise emphasises that high-quality follow-up care for preterm infants requires precisely such interdisciplinary coordination and timely referral to rehabilitation services in order to prevent gaps and duplication of care. The opening of a rehabilitation department directly adjacent to the follow-up clinic, together with the implementation of a structured coordination protocol, constituted the organisational response to this challenge.

2. Aim of the Study

To evaluate the effectiveness of structured coordination between the follow-up clinic and the rehabilitation department with respect to the

timeliness of referral of preterm infants to the MDRT, as well as the dynamics of AIMS and HINE scores under outpatient active function-based rehabilitation with parental involvement.

3. Materials and Methods. Study design and setting

A comparison of two cohorts with a historical control group was conducted from 2023 to 2026. Data on the intervention group were collected prospectively; for the control group the data were obtained from the documentation of the period 2023, and for the 15 control-group infants who were never referred the AIMS and HINE values were retrieved retrospectively from the medical records. The study was conducted at the Department of Follow-Up Observation and Rehabilitation Treatment of Children of the Ivano-Frankivsk Regional Perinatal Centre. Ethical considerations. The study was conducted in accordance with the Declaration of Helsinki. It was non-interventional with respect to the children: all diagnostic assessments (GMA, AIMS, HINE) and all rehabilitation procedures were part of the routine clinical care of the department and were delivered by its own staff according to the department's protocols; no procedure was performed for research purposes, and no child was allocated to a group for the purposes of this study. The authors analysed data generated in the course of that routine care. Written informed consent for the interventions and for the use of depersonalised data was obtained from the legal representatives of all participants. The study was reviewed by the Bioethics Commission of Vasyl Stefanyk Carpathian National University, which issued expert conclusion No. 4/26-9 of 18 June 2026. The study was carried out at the Ivano-Frankivsk Regional Perinatal Centre, with which Vasyl Stefanyk Carpathian National University has a cooperation agreement providing for joint scientific activity. During 2023–2025 the department registered 533 initial patients with a gestational age of 24–36 weeks (2023: n = 182; 2024: n = 190; 2025: n = 161).

Sample formation. The study sample comprised 148 infants discharged from the NICU in 2023–2025 who met the inclusion criteria below and who had undergone the General Movements Assessment in the NICU. Group membership was defined by the calendar year of discharge, which is a fixed attribute of each infant; the inclusion and exclusion criteria were therefore applied before and independently of group assignment. The study sample and the departmental workload figures presented in Table 6 are compiled on different bases and are not nested one within the other: Table 6 counts initial presentations registered at the follow-up clinic in each calendar year, whereas the study sample is defined by the year of discharge and by completed follow-up to 12 months of corrected age, so that an infant discharged late in one calendar year may be registered at the clinic in the next. The figure of 533 initial presentations therefore characterises the workload of the department and is not the sampling frame from which the 148 participants were drawn. All indicators reported in the Results section, in the tables and in the figures were calculated for the study sample (IG n = 84; CG n = 64), with the exception of the departmental activity indicators (Table 6 and Figure 1), which describe the whole contingent of the department for 2023–2025. Because complete follow-up to 12 months of corrected age was an inclusion criterion, the indicator 'missed scheduled visits' refers to visits missed by infants who nevertheless completed the 12-month observation; it therefore characterises adherence within the retained cohort in both groups and does not represent total attrition from the follow-up system.

Inclusion and exclusion criteria. Inclusion criteria: gestational age < 37 weeks, GMA performed in the NICU, discharge from the NICU during 2023–2025, and written informed consent of legal representatives. Exclusion criteria: congenital malformations, chromosomal abnormalities (confirmed by karyotyping), death before 12 months of corrected age, and absence of complete follow-up observation to 12 months of corrected age. Total sample: n = 148 (gestational age 24–36 weeks; mean 29.8 ± 3.4 weeks; birth weight 1312 ± 438 g). The clinical characteristics of the groups are presented in Table 1.

Table 1

Clinical characteristics of study participants (M ± SD or n [%])

Characteristic	IG (n = 84)	CG (n = 64)	p
Gestational age, weeks (M ± SD)	29.6 ± 3.2	30.1 ± 3.7	0.38
Birth weight, g (M ± SD)	1298 ± 421	1331 ± 459	0.65
Sex: boys / girls, n	43 / 41	34 / 30	0.82
Sex: boys / girls, %	51.2 / 48.8	53.1 / 46.9	–
Gestational age < 28 weeks, n (%)	25 (29.8 %)	7 (10.9 %)	0.006
Gestational age 28–31 weeks, n (%)	37 (44.0 %)	32 (50.0 %)	0.47
Gestational age 32–36 weeks, n (%)	22 (26.2 %)	25 (39.1 %)	0.096
GMA: pathological movements, n (%)	52 (61.9 %)	37 (57.8 %)	0.61
NICU stay, days (M ± SD)	34.2 ± 18.6	31.8 ± 16.4	0.42

Note to Table 1. p values for gestational-age categories are given for each category separately; the overall test of the gestational-age distribution between the groups also shows a difference ($\chi^2 = 8.12$; $df = 2$; $p = 0.017$).

Table 2

Comparative characteristics of the organisational models of the IG and CG

Component	IG (structured coordination)	CG (usual practice)	Difference
Shared electronic database (ASKEP)	Yes	No	present vs absent
Standardised referral form	Yes	No	present vs absent
MDRT meetings ≥ once every 2 weeks	Yes	No	present vs absent
Feedback after each course	Yes	No	present vs partial
Development of an individual rehabilitation plan	Yes	Partly	present vs partial
Time from discharge to PT, weeks	7.2 ± 1.4	14.6 ± 3.8	p < 0.001
Referral coverage, %	91.7	46.9	p < 0.001

Group formation and organisational models. The intervention group (IG, n = 84) comprised infants discharged in 2024–2025, after the opening of the rehabilitation department and the introduction of the structured coordination protocol. The control group (CG, n = 64) comprised infants discharged in 2023, before the systematisation of interdepartmental interaction. In both periods the rehabilitation was delivered within the same department and by the same specialists; the groups differ in the organisational route by which a child reached that department – the presence or absence of a standardised electronic referral, an individual rehabilitation plan, regular team meetings and structured feedback – and not in the provider of care or in the availability of rehabilitation as such. Because individual rehabilitation plans were not drawn up in the CG, however, the content of the rehabilitation actually delivered in that group was not documented and its equivalence to the IG cannot be verified. The IG protocol included: (1) a shared electronic patient database (the ASKEP e-health system) with joint access for the follow-up clinic and the rehabilitation department; (2) a standardised electronic referral form (GMA result, current corrected age, clinical justification); (3) regular MDRT meetings at least once every two weeks; and (4) feedback from the rehabilitation department to the follow-up clinic after each course, including AIMS and HINE results and revised goals of the individual rehabilitation plan. A comparison of the organisational models is presented in Table 2.

Clinical pathway. The stepwise clinical pathway of the infant from the NICU to the rehabilitation department is presented in Table 3.

Table 3

Clinical pathway of the preterm infant from the NICU to the rehabilitation department

Stage	Provider	Instrument	Content / transition criterion
NICU	GMA-certified specialist	GMA (Prechtl)	Assessment of spontaneous movements. A pathological or absent pattern is recorded in the discharge summary
Follow-up clinic (from 1 month corrected age)	Paediatrician-neonatologist, neurologist	Clinical examination	Delay or deviation → electronic referral; otherwise referral from the treating physician or primary care
Rehabilitation department – baseline assessment (from 2 months corrected age)	Physical and rehabilitation medicine (PRM) physician + physical therapist (MDRT)	AIMS + HINE	Development of the individual rehabilitation plan; definition of goals and scope of rehabilitation
Outpatient course (10–14 sessions)	Physical therapist (± occupational therapist), other specialists as required	Active function-based rehabilitation	Daily or on alternate days: skill acquisition according to the individual plan; parent training in separate sessions; home programme between courses
MDRT meeting + repeat assessment	PRM physician + physical therapist	AIMS + HINE	Revision of the individual plan; repeat course or long-term rehabilitation

Assessment in the NICU (GMA). All 148 infants in the sample underwent GMA according to the Prechtl standard [1]: video recording of spontaneous motor activity lasting at least 3 minutes during the writhing movements period (31–36 weeks of postmenstrual age) and, where possible, during the fidgety movements period (3–5 months of corrected age). Video recording was performed with the written consent of the parents. Assessment was carried out by a specialist certified in the basic GMA course. Results were classified as normal (N), poor repertoire (PR), cramped-synchronised (CS) or chaotic (Ch). The conclusion was recorded in the discharge summary and transmitted to the follow-up clinic.

Assessment in the rehabilitation department (AIMS and HINE). AIMS and HINE data were obtained for all 148 infants of both groups. For infants referred to the MDRT, the assessments were performed prospectively by the rehabilitation department. For the 15 CG infants who received no referral to the MDRT during the first year, the corresponding AIMS and HINE values were retrieved retrospectively from the medical records of the follow-up clinic, where these infants continued to be observed. These 15 infants were not left without rehabilitation. They attended a physical therapist of the same department and were treated by the same specialists as all other participants, but without having passed through a referral route: no referral was recorded for them, and consequently no individual rehabilitation plan and no structured feedback to the follow-up clinic were generated. The interval from discharge to the first physical therapist appointment is therefore defined for them and they are included in that analysis. Time points of assessment. Two time points are used throughout this paper, identically for both groups and for the records retrieved retrospectively. The baseline assessment (AIMS and HINE) was performed before the start of the rehabilitation course. The repeat assessment was anchored to corrected age and performed within the window of 6 months of corrected age, and not to the completion of the course: the duration of a course varied, since 10–14 sessions could be delivered at different frequencies – for example every third day or less often – so the completion of a course does not define a comparable moment between children, whereas corrected age does. The repeat point therefore coincides with the age for which an age-specific HINE cut-off score for infants born preterm is defined [15]. Two consequences follow and are stated here explicitly. First, the values obtained at the repeat assessment, and likewise the AIMS results at 6 and 12 months of corrected age, are comparable between the groups, because they were obtained at the same

corrected age. Second, the baseline assessment was not aligned in this way: the course began on average 7.2 weeks after discharge in the IG and 14.6 weeks in the CG, so the baseline values were obtained at different ages and the interval between the two assessments was correspondingly longer in the IG. The exact individual corrected age on the day of each examination was not separately recorded: the repeat assessments were scheduled by protocol at 6 and 12 months of corrected age, so the groups are aligned at the scheduled age point, but the exact age on the day of the visit is absent from the records and could not be used as a covariate for the baseline difference. All assessments in both periods were performed by the same specialists of the MDRT – the physical and rehabilitation medicine physician and the physical therapist of the department – following the single algorithm presented in Table 3; the composition of the assessors did not change between the periods. The assessment was not blinded, since the period to which an infant belonged was known to the specialists. The physical therapist performed the baseline assessment using two standardised scales. The Alberta Infant Motor Scale (AIMS) is an observational instrument comprising 58 items in 4 body positions (prone – 21, supine – 9, sitting – 12, standing – 16); a score below the 10th percentile is considered an indication for referral to the MDRT for assessment of motor development. AIMS makes it possible not only to quantify the level of motor development but also to identify qualitative features of movement patterns – asymmetry, limitation of particular positions, compensatory strategies – which directly determine the content of the individual rehabilitation plan.

The Hammersmith Infant Neurological Examination (HINE) is a structured examination whose scorable neurological section comprises 26 items in five subsections (cranial nerve function, posture, movements, tone, and reflexes and reactions), each scored from 0 to 3, giving a maximum global score of 78 [15]. Two distinct kinds of reference value exist for this instrument and are kept separate here. Optimality scores are derived from typically developing term-born infants and are defined at 9 and 12 months (≥ 73 points); at 3 and 6 months the corresponding values for term-born infants are ≥ 67 points and a median of 70 points. For infants born preterm the concept of optimality is difficult to apply, and age-specific cut-off scores are used instead: in a cohort of 1229 infants born preterm, cut-offs of 58 points at 3 months, 64 points at 6 months and 69 points at 9 and 12 months identified significantly delayed performance and/or cerebral palsy at 2 years [15]. The present study therefore uses the 6-month cut-off of 64 points as the reference value for the repeat assessment. HINE provides monitoring of the dynamics of neurological status in response to intervention and serves as an additional prognostic marker: a global score below 40 has been reported only in association with severe cerebral palsy. Repeat AIMS and HINE assessments were performed at the key time points of corrected age – 6 months for HINE and AIMS, and additionally 12 months for AIMS – irrespective of the moment at which a particular rehabilitation course was completed.

Outpatient rehabilitation interventions: principles and content. The rehabilitation programme of the department is built on the principles of active function-based rehabilitation (activity-based rehabilitation, task-oriented approach) – an approach recognised by current systematic evidence as the most substantiated for children at risk of motor impairment [6; 8; 11]. The key principle is that the rehabilitative intervention is directed towards the acquisition of a specific age-appropriate motor skill defined as a goal of the individual rehabilitation plan, rather than towards passive correction of tone or reflexes. The infant is an active participant in the therapeutic process, and sessions are structured in the form of play, which corresponds to the neurobiological mechanisms of motor learning in early childhood.

The individual rehabilitation plan was developed by the PRM physician together with the physical therapist on the basis of the baseline AIMS and HINE results and was approved at an MDRT meeting. The course comprised 10–14 sessions of 40–50 minutes. The frequency was not fixed: sessions were conducted daily, on alternate days or at intervals of several days, depending on the needs and the condition of the particular child. The same number of sessions could therefore be delivered over markedly different periods of time. The detailed content of the rehabilitation interventions by corrected age is presented in Table 4.

Table 4

Content of outpatient rehabilitation interventions by corrected age of the infant

Age (corrected)	Rehabilitation goal (per individual plan)	Frequency	Specific tasks and techniques
2–4 months	Head control; stimulation of grasping reactions; trunk symmetry	10–14 sessions; daily, on alternate days or at intervals of several days, depending on the child's needs and condition	Handling in the prone position with forearm support; positioning to stimulate head lifting; tactile and proprioceptive stimulation of the palms; training of visual tracking; parent training in correct holding and positioning at home
5–6 months	Rolling from supine to prone and back; support on extended arms	10–14 sessions; daily, on alternate days or at intervals of several days, depending on the child's needs and condition	Active facilitation of rolling through the pelvis and shoulder girdle; tasks involving reaching for a toy laterally; exercises on a therapy ball to stimulate equilibrium reactions; development of protective arm support; home programme: repetition on the changing table 3–5 times a day
7–9 months	Pulling to sit; commando crawling and crawling on hands and knees; weight shifting	10–14 sessions; daily, on alternate days or at intervals of several days, depending on the child's needs and condition	Play tasks involving reaching for objects from a supported sitting position; stimulation of alternating weight bearing on the arms in the quadruped position; active crawling towards a motivating object; training of symmetrical unsupported sitting; home programme: floor play encouraging active movement
10–12 months	Pulling to stand; walking with support; fine motor skills	10–14 sessions; daily, on alternate days or at intervals of several days, depending on the child's needs and condition	Tasks involving standing up with gradual reduction of external support; side-stepping along a support; walking with hand support; games involving throwing and picking up objects; occupational therapy for fine motor skills and sensory integration where indicated; home programme: stimulation of independent attempts to stand and walk

Table 5

Forms of parental involvement in the rehabilitation process

Stage of parental involvement	Format	Frequency	Purpose
Training during sessions	Parents observe and repeat exercises under the guidance of the physical therapist	During part of the sessions of the course (not necessarily every session)	Acquisition of correct exercise and handling technique
Home programme between courses	Written and/or video instructions with individual tasks	Daily, 15–20 minutes	Ensuring continuity of the therapeutic effect between courses
Positioning at home	Correct positioning during sleep, feeding and play	Continuously (throughout the day)	Prevention of pathological motor stereotypes; maintenance of acquired skills
Handling in everyday care	Skills of transferring, holding, bathing and dressing	Continuously	Formation of normative movement patterns in the context of everyday care
MDRT meeting (with parental participation)	Parents receive feedback on assessment results and new goals of the individual plan	After each course	Involvement of parents in planning the rehabilitation process

During the sessions the physical therapist applied the following therapeutic strategies. First, handling and positioning: correct therapeutic handling of the infant during transfers, holding and exercises, ensuring optimal alignment of the trunk and limbs and shaping normotypical movement patterns within each session. Second, sensorimotor stimulation: the use of tactile, proprioceptive and vestibular stimuli to prepare the nervous system for active motor tasks – exercises on a therapy ball, tactile play with surfaces of different textures, and stimulation of the feet to activate support reactions. Third, reaching and manipulation tasks: tasks requiring the infant to move actively towards a target object (a toy) in various body positions, with gradual increases in difficulty by distance, height and weight of the object. Fourth, training of locomotor skills: the sequential development of rolling, crawling and walking through gradual reduction of external support and increasing independence of movement execution.

Importantly, the programme did not include passive neurodevelopmental techniques, whose effectiveness is not confirmed by evidence-based research in preterm infants. The programme was built on active motor learning, in line with contemporary neurobiological data on the formation of cortical motor maps through the infant's own motor activity [6]. The design does not separate the contribution of individual components of the intervention, so no statement is made here about the share of the observed effect attributable to any one of them.

Parental involvement and the home programme. Parents are integral participants in the rehabilitation process. According to the protocol, during part of the sessions of the course (not necessarily every session) parents were directly taught to perform the exercises: they observed the actions of the physical therapist and repeated them under supervision, receiving feedback on the correctness of technique. Between courses the family carried out a home programme of 15–20 minutes daily, comprising the same exercises practised during the sessions, supplemented by recommendations on positioning throughout the day (during sleep, feeding and play) and on correct handling technique during everyday care (transfers, bathing, dressing). Parents received written and/or video instructions with individual tasks linked to specific goals of the individual rehabilitation plan. The structure of parental involvement is presented in Table 5.

Parental involvement is clinically justified from the standpoint of continuity of intervention between courses: the home programme is intended to extend therapeutic exposure beyond the sessions themselves. Adherence to the home programme was not measured in this study, so the volume of practice actually performed at home is unknown, and no equivalence between it and any given number of physical therapy sessions is claimed. Parental participation is nevertheless the mechanism by which the outpatient model seeks to compensate for its lower intensity compared with inpatient programmes.

Statistical analysis. SPSS Statistics 26.0 was used. Normality of distribution was assessed using the Shapiro-Wilk test. Frequencies were compared between groups using Pearson's χ^2 test (with expected frequencies > 5) or Fisher's exact test. For within-group dynamics before and after intervention the paired t-test was applied. The level of statistical significance was set as two-tailed $p < 0.05$. For continuous variables between independent groups Student's t-test (equal variances assumed) was used as the main test; equality of variances was checked with the F-test, and where it was rejected (HINE at the 6-month repeat assessment: $F = 1.78$, $p = 0.014$; interval to the first physical therapist appointment: $F = 7.37$, $p < 0.001$) the Welch test was additionally computed as a sensitivity analysis, which did not change any conclusion (HINE: $t = 7.09$, $df = 112.8$, $p < 0.001$; interval: $t = 14.83$, $df = 76.1$, $p < 0.001$). Effect estimates are reported with 95 % confidence intervals: for mean differences the interval was obtained as the difference ± t (0.975; df) × standard error of the difference; for risk differences the Wald interval for the difference of two proportions was used, and for odds ratios the Woolf logit interval. Hedges' g was calculated as Cohen's d from the pooled standard deviation multiplied by the small-sample correction factor J. The actual number of observations entering each analysis is stated in the corresponding row of Table 7. For the HINE assessed at baseline and at the 6-month repeat assessment, the group × time interaction was tested as a between-group comparison of individual change scores, which is algebraically equivalent to the interaction term of a 2 × 2 repeated-measures analysis of variance. As a

sensitivity analysis, the Holm–Bonferroni procedure was applied to the six principal comparisons (timely referral, interval to the first physical therapist appointment, HINE at the 6-month repeat assessment, AIMS at 6 and at 12 months, missed follow-up visits); the procedure was applied post hoc, since no primary outcome had been prespecified. All indicators were calculated for the complete groups (IG n = 84; CG n = 64), since all study participants underwent AIMS and HINE assessment. The analysed dataset contained no missing values for AIMS, HINE or GMA, because complete follow-up to 12 months of corrected age with complete assessments was an inclusion criterion; no imputation was therefore performed and no sensitivity analysis for missing data was required. Variables that were not recorded at all (individual corrected age at each assessment, the number of delivered sessions, the duration of courses and adherence to the home programme) are absent by design rather than missing, and could not be analysed.

4. Results and discussion

Dynamics of departmental activity (2023–2025). The actual activity indicators of the department over three years are presented in Table 6 and illustrated in Figure 1. The total number of initial visits increased 6.3-fold, from 472 in 2023 to 2969 in 2025. Rehabilitation coverage of preterm infants almost doubled after the National Health Service license was obtained: from 342 children in 2024 to 623 in 2025. The number of initial presentations of preterm infants with a gestational age of 24–36 weeks remained relatively stable (161–190 per year).

GMA in the NICU. Of the 148 infants examined, pathological general movements were recorded in 89 (60.1 %): poor repertoire (PR) in 54 (36.5 %) and cramped-synchronised movements (CS) in 35 (23.6 %). No chaotic movements were registered in the sample. The distribution did not differ statistically between the IG and CG (52/84, 61.9 % versus 37/64, 57.8 %; $\chi^2 = 0.25$; $p = 0.61$; risk difference 4.1 percentage points, 95 % CI −11.9 to 20.0), which is consistent with comparability of the groups with respect to the baseline neurological risk profile. The groups did not differ in sex, birth weight, mean gestational age or duration of NICU stay (Table 1), but they did differ in the distribution of gestational-age categories: the IG contained a significantly higher proportion of infants born before 28 weeks – 25 of 84 (29.8 %) versus 7 of 64 (10.9 %); $\chi^2 = 7.60$; $p = 0.006$.

Table 6

Key activity indicators of the Department of Follow-Up Observation and Rehabilitation Treatment of Children (2023–2025)

Indicator	2023	2024	2025
Total visits, n	1982	10 315	11 295
Initial visits, n	472	2658	2969
Preterm infants 24–36 weeks (initial), n	182	190	161
Children who received rehabilitation, n	n/a*	342	623

*Note to Table 6. The table characterises the workload of the department and counts initial presentations registered at the follow-up clinic in each calendar year. It is not the sampling frame of the study: the study sample was formed on a different basis (see 'Sample formation'), so the two sets of figures are compiled differently and are not comparable at the level of gestational-age subcategories. * The rehabilitation service began operating in 2023, but a separate record of children who completed a rehabilitation course was not maintained until the National Health Service licence was obtained in 2024; the indicator for 2023 is therefore unavailable rather than zero.*

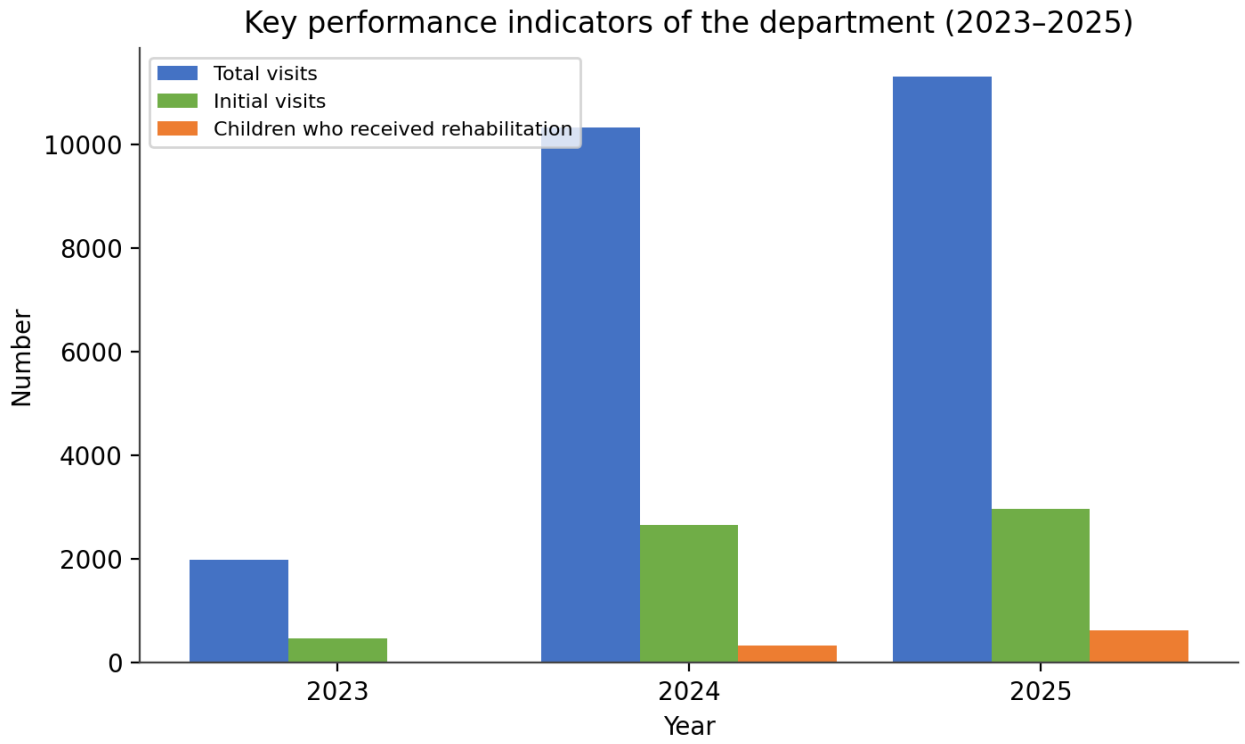

Figure 1. Dynamics of key activity indicators of the department (2023–2025). Rehabilitation coverage increased from 342 children in 2024 to 623 in 2025 after the National Health Service licence was obtained

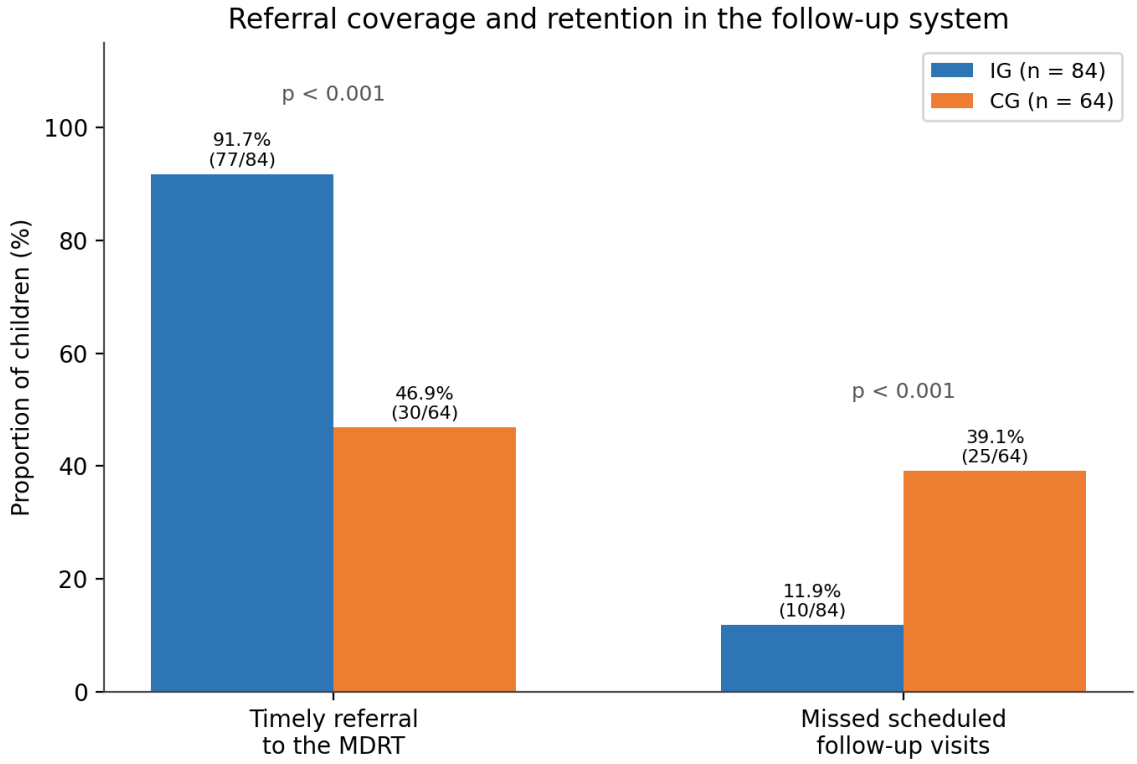

Figure 2. Referral coverage and missed scheduled visits: proportion of children referred to the MDRT in a timely manner and proportion of children who missed a scheduled follow-up visit, %. IG n = 84; CG n = 64

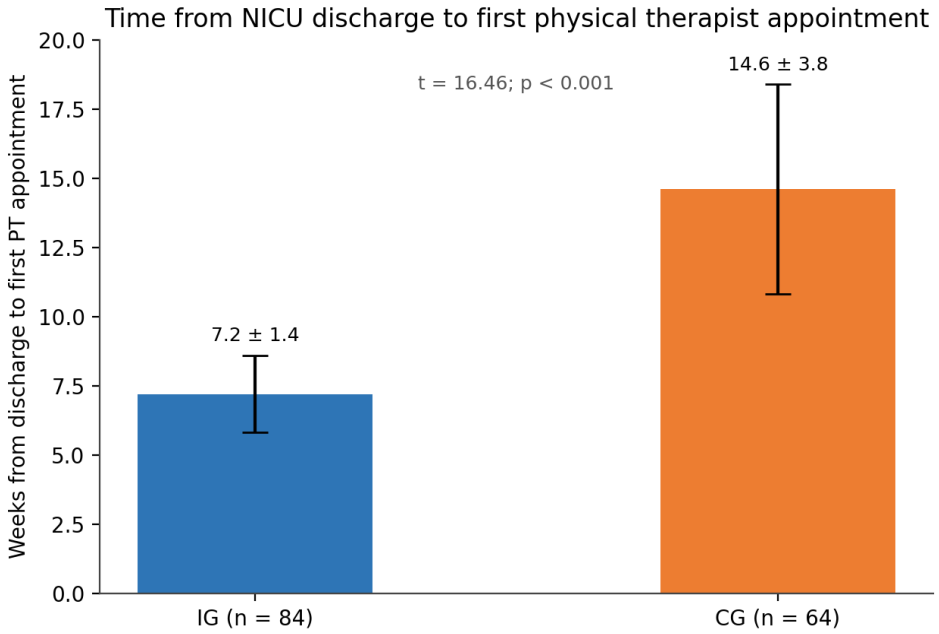

Figure 3. Time from NICU discharge to the first physical therapist appointment (M ± SD, weeks). IG n = 84; CG n = 64; t = 16.46; p < 0.001

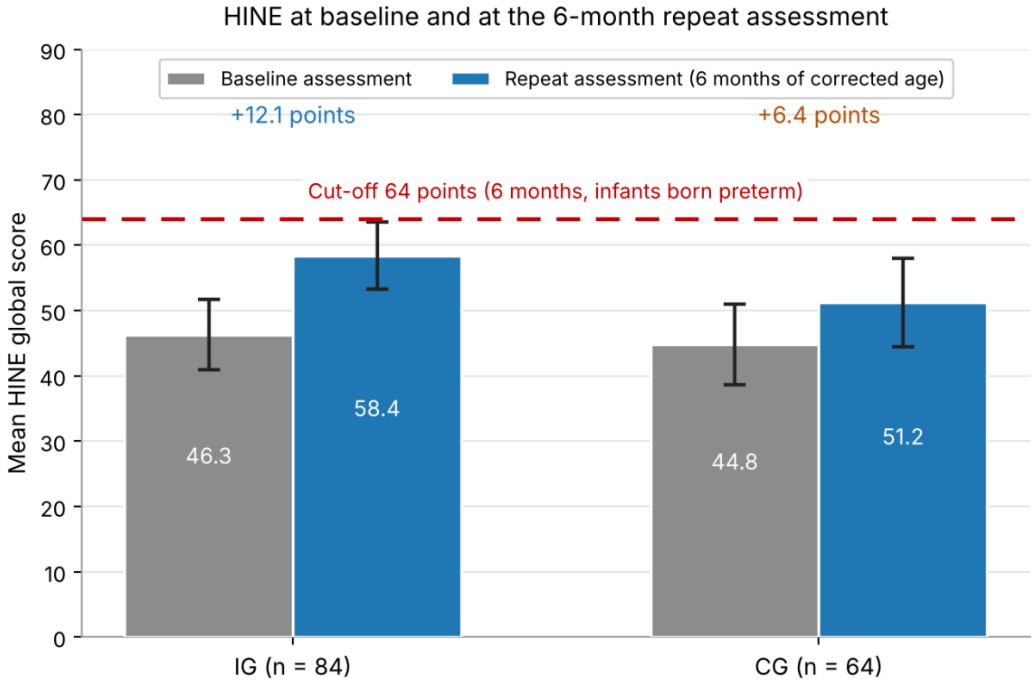

Figure 4. Mean HINE score at the baseline assessment and at the repeat assessment performed within the window of 6 months of corrected age, in the IG (n = 84) and CG (n = 64), M ± SD. The dashed line indicates the 6-month cut-off score of 64 points proposed for infants born preterm [15]. t = 7.36; p < 0.001 between groups

Timeliness of referral and MDRT coverage. Timely electronic referral to the MDRT of the rehabilitation department was received by 77 of 84 IG infants (91.7 %) and by only 30 of 64 CG infants (46.9 %; χ^2 = 36.39; p < 0.001; risk difference 44.8 percentage points, 95 % CI 31.2–58.4; OR 12.5, 95 % CI 5.0–31.2). In the CG the structured protocol did not yet exist, and referral took place in the ordinary way, at the discretion of the follow-up clinic physician and without a standardised electronic form. Of the 64 CG infants, 49 were referred to the rehabilitation department in

this ordinary way – 30 of them within the time frame defined here as timely and 19 later than 14 weeks after discharge – while for the remaining 15 (23.4 %) no referral was recorded at all, although these infants did reach a physical therapist of the same department. The mean interval from NICU discharge to the first physical therapist appointment was 7.2 ± 1.4 weeks in the IG (n = 84) versus 14.6 ± 3.8 weeks in the CG (n = 64; t = 16.46; p < 0.001; mean difference 7.4 weeks, 95 % CI 6.5–8.3; Hedges' g = 2.72). The referral coverage and missed-visit indicators are shown in Figure 2, and the distribution of referral intervals in Figure 3.

Baseline assessment in the rehabilitation department. An AIMS score below the 10th percentile at baseline assessment was found in 78 of 84 IG infants (92.9 %) and in 35 of 64 CG infants (54.7 %; $\chi^2 = 29.31$; p < 0.001). Since all infants in both groups underwent assessment, this difference is unlikely to be attributable to selection; one possible explanation is the different timing of the baseline assessment rather than baseline severity, although the available data do not allow this explanation to be tested: baseline HINE scores did not differ statistically – 46.3 ± 5.4 (IG) versus 44.8 ± 6.2 (CG; t = 1.57; p = 0.12). In the IG the baseline assessment was performed on average 7.2 weeks after discharge, whereas in the CG it was performed at 14.6 weeks, by which time some infants had already partially compensated for their initial lag through spontaneous maturation. The baseline AIMS indicator in the CG may therefore underestimate the prevalence of motor delay in the early period after discharge; this comparison is treated as descriptive. Qualitative analysis of AIMS in the IG (n = 84) revealed delayed head control and forearm support in 57 infants (67.9 %), impaired trunk symmetry in 45 (53.6 %), delayed rolling in 40 (47.6 %) and limitation of postural equilibrium reactions in 37 (44.0 %). These findings directly determined the priority content of the individual rehabilitation plans.

HINE dynamics at the 6-month repeat assessment (Figure 4). The repeat assessment was performed within the window of 6 months of corrected age in both groups, irrespective of when the rehabilitation course had been completed. The rehabilitation preceding it differed between the groups: in the IG it was the structured course delivered by the MDRT, whereas in the CG it was delivered either by the MDRT after a late referral (49 infants) or outside the structured referral route, without a documented plan or recorded content (15 infants). The comparison is therefore between a structured, documented intervention and heterogeneous usual care, not between intervention and no intervention. At the 6-month repeat assessment the mean HINE score in the IG (n = 84) had increased by 12.1 ± 6.3 points, from 46.3 ± 5.4 to 58.4 ± 5.1 (paired t = 17.60; df = 83; p < 0.001). In the CG (n = 64) the increase was less pronounced: +6.4 ± 5.7 points (from 44.8 ± 6.2 to 51.2 ± 6.8; paired t = 9.06; df = 63; p < 0.001). The between-group difference in HINE scores at the repeat assessment was statistically significant (t = 7.36; df = 146; p < 0.001; mean difference 7.2 points, 95 % CI 5.3–9.1; Hedges' g = 1.22). The group × time interaction was also significant: the mean increase differed by 5.7 points in favour of the IG (12.1 vs 6.4; t = 5.70; df = 146; p < 0.001; 95 % CI 3.7–7.7; Hedges' g = 0.94; equivalent F (1.146) = 32.5), that is, the mean change from baseline differed between the groups. At the repeat assessment the mean score remained below the 6-month cut-off of 64 points proposed for infants born preterm [15] in both groups (IG 58.4 points; CG 51.2 points), the intervention group being closer to it. The greatest increase in the IG was observed in the domains of tone (+4.1 points) and postural reactions (+3.8 points), which is consistent with the content of active function-based rehabilitation directed towards the acquisition of postural skills.

Dynamics of motor development according to AIMS (Figure 5). Age-appropriate AIMS scores at 6 months of corrected age were achieved by 44 of 84 IG infants (52.4 %) versus 20 of 64 CG infants (31.3 %; $\chi^2 = 6.61$; p = 0.010; risk difference 21.1 percentage points, 95 % CI 5.5–36.7; OR 2.42, 95 % CI 1.23–4.78). At 12 months of corrected age the corresponding figures were 60 of 84 (71.4 %) in the IG versus 29 of 64 (45.3 %) in the CG ($\chi^2 = 10.33$; p = 0.001; risk difference 26.1 percentage points, 95 % CI 10.6–41.7; OR 3.02, 95 % CI 1.52–5.97). In the subgroup of infants with a gestational age < 28 weeks (IG n = 25, CG n = 7), age-appropriate AIMS scores at 12 months were achieved by 15 of 25 (60.0 %) in the IG and 2 of 7 (28.6 %) in the CG; despite the marked difference in proportions, it did not reach statistical significance owing to the small subgroup sizes; because the expected frequencies were below 5,

Fisher's exact test was used (p = 0.209), and these data are therefore presented descriptively. All six principal comparisons retained significance after Holm-Bonferroni correction. Summary comparative data are presented in Table 7.

Table 7

Comparative characteristics of key indicators between the intervention and control groups

Indicator	IG	CG	Test	p	Effect size (95 % CI)
GMA: pathological movements in the NICU, n (%)	52/84 (61.9)	37/64 (57.8)	$\chi^2 = 0.25$	0.61	RD 4.1 pp (−11.9 to 20.0)
Timely referral to the MDRT, n (%)	77/84 (91.7)	30/64 (46.9)	$\chi^2 = 36.39$	< 0.001	RD 44.8 pp (31.2 to 58.4); OR 12.5 (5.0 to 31.2)
Time from discharge to the first PT appointment, weeks (M ± SD)	7.2 ± 1.4 (n = 84)	14.6 ± 3.8 (n = 64)	t = 16.46	< 0.001	MD 7.4 weeks (6.5 to 8.3); g = 2.72
AIMS < 10th percentile at baseline, n (%)	78/84 (92.9)	35/64 (54.7)	$\chi^2 = 29.31$	< 0.001	RD 38.2 pp (24.8 to 51.6); OR 10.77 (4.10 to 28.28)
HINE: mean score at baseline (M ± SD)	46.3 ± 5.4 (n = 84)	44.8 ± 6.2 (n = 64)	t = 1.57	0.12	MD 1.5 points (−0.4 to 3.4)
HINE: mean score at repeat assessment (M ± SD)	58.4 ± 5.1 (n = 84)	51.2 ± 6.8 (n = 64)	t = 7.36	< 0.001	MD 7.2 points (5.3 to 9.1); g = 1.22
HINE: change from baseline (M) – group × time	+12.1 (n = 84)	+6.4 (n = 64)	t = 5.70	< 0.001	MD of change 5.7 points (3.7 to 7.7); g = 0.94; F(1, 146) = 32.5
AIMS: age-appropriate at 6 months corrected age, n (%)	44/84 (52.4)	20/64 (31.3)	$\chi^2 = 6.61$	0.010	RD 21.1 pp (5.5 to 36.7); OR 2.42 (1.23 to 4.78)
AIMS: age-appropriate at 12 months corrected age, n (%)	60/84 (71.4)	29/64 (45.3)	$\chi^2 = 10.33$	0.001	RD 26.1 pp (10.6 to 41.7); OR 3.02 (1.52 to 5.97)
Missed scheduled visits among participants with completed follow-up, n (%)	10/84 (11.9)	25/64 (39.1)	$\chi^2 = 14.84$	< 0.001	RD −27.2 pp (−41.0 to −13.3); OR 0.21 (0.09 to 0.48)

Note to Table 7. RD – risk difference in percentage points; OR – odds ratio; MD – mean difference; g – Hedges' g. Confidence intervals: Wald for risk differences, Woolf logit for odds ratios, t-based for mean differences. The interval from discharge to the first physical therapist appointment is defined for all 64 CG infants: 49 of them attended after a referral to the MDRT, and the remaining 15, for whom no referral was recorded, attended a physical therapist of the same department outside the structured referral route. The row 'HINE: change from baseline' presents the group × time interaction as a comparison of individual change scores.

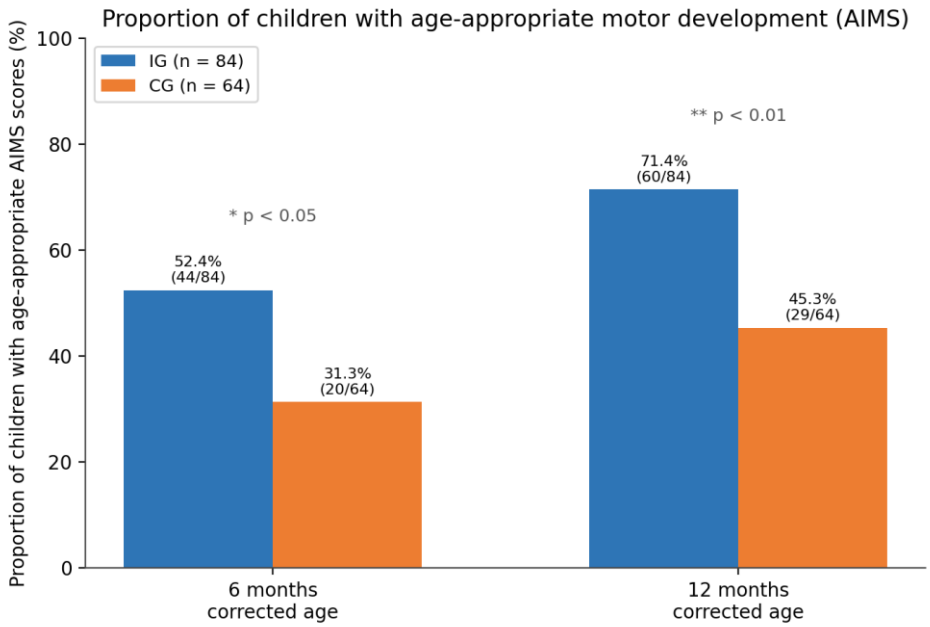

Figure 5. Proportion of children with age-appropriate AIMS scores at 6 and 12 months of corrected age in the IG (n = 84) and CG (n = 64), %. Absolute values are shown above the bars. * – p < 0.05; ** – p < 0.01 between groups

Missed scheduled visits among participants with completed follow-up. The rate of missed scheduled follow-up visits was 11.9 % (10/84) in the IG versus 39.1 % (25/64) in the CG (χ^2 = 14.84; p < 0.001; risk difference −27.2 percentage points, 95 % CI −41.0 to −13.3; OR 0.21, 95 % CI 0.09–0.48). The indicator covers only children who completed the 12-month observation, so overall retention in the follow-up system was not assessed. Among IG families whose infants attended sessions with high parental compliance (n = 41), the rate of missed visits was lower still – 7.3 % (3/41).

Discussion. The differences identified between the IG and CG appear to be predominantly organisational rather than clinical in nature: the groups did not differ in the baseline neurological profile (GMA and HINE at initial examination), yet differed substantially in the timeliness of referral. One imbalance deserves emphasis: the IG contained almost three times the proportion of infants born before 28 weeks (29.8 % vs 10.9 %; p = 0.006). These are the infants at highest risk of motor impairment. It would be tempting to argue that the imbalance therefore works against the intervention group and renders the estimate conservative, but that argument cannot be made from these data: without multivariable adjustment, and with other prognostic characteristics (neonatal complications, duration of respiratory support, social factors) not recorded, the direction of the net bias cannot be established. The imbalance is reported as an unresolved threat to the comparison rather than as a factor of known direction. This is consistent with an association between the structured coordination protocol and the observed improvement, although the design does not allow an independent causal contribution to be established. It should also be stressed that the control group was not an untreated group. Its infants received rehabilitation in the same department and from the same specialists, but later and, for a proportion of them, without a recorded referral and therefore without an individual plan or structured feedback. The comparison therefore concerns the organisation and timeliness of care, not the presence or absence of rehabilitation and not the provider of it. This narrows the range of possible explanations for the observed difference, since the staff, the setting and the clinical approach of the department were common to both groups; it does not, however, exclude the period effect inherent in a historical comparison, nor the fact that the content of the rehabilitation delivered in the CG was not documented and could not be compared. Seppänen et al. [16] showed that the formal regulation of follow-up programmes is associated with the actual coverage of children by services; the present data from a single institution are consistent with that observation but, being uncontrolled, do not test it.

The choice of active function-based rehabilitation as the principal therapeutic approach is a fundamental methodological decision. Unlike passive neurodevelopmental techniques, whose effectiveness in prematurity is not confirmed by contemporary evidence reviews, the active approach rests on the neurobiological mechanisms of motor learning: cortical motor maps are formed and consolidated exclusively through the infant's own motor activity in the context of functionally meaningful tasks [6]. Novak et al. [8], in a consensus review published in JAMA Pediatrics, state directly that the early application of evidence-based, functionally oriented interventions is a condition for optimising neuroplasticity in children at risk of cerebral palsy.

Qualitative analysis of baseline AIMS in the IG revealed a delay profile specific to prematurity: a predominant deficit of head control and forearm support (67.9 %), impaired trunk symmetry (53.6 %) and delayed rolling (47.6 %). These deficits directly determined the priority content of the individual rehabilitation plans in the first two age windows (2–4 and 5–6 months). Such an approach – proceeding from a specific functional deficit to a specific therapeutic task – realises the principle of personalised rehabilitation. Ko and Lim [5], in a comparative study of 252 infants, showed that the structure of the AIMS lag in preterm infants is specific and requires targeted rather than uniform intervention.

The dynamics of HINE are informative for evaluating the course of active function-based rehabilitation. The increase in the IG amounted to 12.1 points (from 46.3 to 58.4) against 6.4 points in the CG, whose baseline score did not differ statistically from that of the IG. Neurological maturation contributes to the increase in both groups. For the outcomes anchored to corrected age – HINE at the 6-month repeat assessment and AIMS at 6 and 12 months – both groups were examined at the same scheduled age. The groups nevertheless differed in gestational-age composition and in baseline AIMS, and the baseline HINE was obtained at different ages; the absence of a statistically significant difference in individual baseline measures does not establish equivalence, so neither baseline neurological risk nor differential maturation can be excluded as a contributor to the differences observed. For the comparison of increments this does not hold: because the repeat assessment was anchored to corrected age while the baseline was not, the interval between the two assessments was on average some seven weeks longer in the IG, and part of the larger increase in that group may reflect the longer interval rather than the intervention; the two cannot be separated in these data. It should be noted, however, that the longer interval is itself a consequence of the earlier start of rehabilitation, which is the very exposure under study. The actual amount of intervention delivered was not recorded, so no statement can be made about the volume of therapy received by either group. For this reason the principal evidence of this study rests on the status attained at a fixed corrected age – HINE at 6 months and AIMS at 6 and 12 months, all obtained at the same age in both groups – whereas the comparison of increments is reported with the reservation stated above. Romeo et al. [14] showed that a progressive increase in HINE between 3 and 12 months is an independent predictor of better functional outcomes at 2 years. The present study did not follow the children to 2 years and therefore cannot confirm or refute that prognostic relationship; it is cited only as the rationale for monitoring HINE. Uusitalo et al. [17] further demonstrated in a prospective cohort that HINE scores are associated with long-term cognitive outcome in children born very preterm, which underlines the prognostic value of monitoring this indicator. The absolute level of the scores observed here warrants separate comment. In the cohort in which the cut-offs were derived, the median global HINE score at 6 months of corrected age was 66 points (interquartile range 64–70; full range 53–74) among infants with typical or mildly delayed performance at 2 years, 62 points (58–64; 43–70) among those with significantly delayed performance, and 45 points (35–56; 28–65) among those who developed cerebral palsy [15]. The means obtained in the present study – 58.4 points in the IG and 51.2 points in the CG – lie below the values reported for infants born at term, which is consistent with published evidence that infants born preterm attain lower HINE scores than their term-born peers at every age examined, even in the absence of cerebral palsy [12]. They also lie below the values reported for low-risk infants born preterm. Two features of the present sample plausibly contribute to this difference. First, its gestational-age composition: the sample spans 24–36 weeks and almost one third of the intervention group was born before 28 weeks, whereas the

reference cohorts consist predominantly of infants born closer to term. Second, its selection by neurological risk: pathological general movements were recorded in 60.1 % of the sample and an AIMS score below the 10th percentile in 92.9 % of the intervention group at baseline, whereas the reference values were obtained in unselected or low-risk cohorts. The relative contribution of these two factors cannot be quantified from the present data, and establishing HINE reference values and age-specific cut-off scores separately for infants born very preterm is therefore a priority for further research.

The AIMS results are consistent with the HINE dynamics and corroborate them at the level of functional outcome: the proportion of children with age-appropriate motor development in the IG significantly exceeded that in the CG both at 6 months (52.4 % versus 31.3 %; $p = 0.010$) and at 12 months of corrected age (71.4 % versus 45.3 %; $p = 0.001$). Notably, the effect size increased with age – the absolute difference rose from 21.1 to 26.1 percentage points – which corresponds to the cumulative nature of early intervention: the earlier rehabilitation is initiated, the greater the volume of therapeutic exposure accumulated by 12 months. The subgroup of infants with a gestational age < 28 weeks requires particular caution in interpretation: despite a twofold difference in proportions (60.0 % versus 28.6 %), the small subgroup sizes (25 and 7 infants) did not permit statistical confirmation, and these data are therefore descriptive and require verification in a dedicated sample of extremely preterm infants.

The role of parental compliance merits separate analysis. The difference in the rate of missed scheduled visits (11.9 % versus 39.1 %) describes adherence within the retained cohort. Further analysis showed that among IG families with high parental compliance at sessions the rate of missed visits was lower still (7.3 % versus 11.9 %), which is consistent with an additional contribution of parental compliance, although this subgroup analysis is exploratory and does not establish an independent effect. Ravarian et al. [13] showed that timeliness of physician referral and parental awareness are independent predictors of attendance at follow-up and early intervention services after NICU discharge. The present analysis was not multivariable and therefore does not establish independent predictors; the observed association is reported descriptively.

The departmental activity data (Table 6) show that rehabilitation coverage increased from 342 to 623 children after the National Health Service licence was obtained in 2024, without any fundamental change in the methods of intervention and within the same clinical facility. This is an activity indicator of a single institution; it describes growth in the volume of services delivered and is not a test of the reproducibility or scalability of the model, which would require implementation in other institutions. This is compatible with an organisational and licensing explanation for the expansion of coverage – rather than with the renewal of equipment or techniques – although with a single institution and no concurrent comparator the contribution of the licence cannot be separated from other changes occurring over the same period. Nordhov et al. [7], in a randomised controlled trial of a modified Mother–Infant Transaction Program delivered as daily sessions during the week before discharge and four home visits over the first three months after discharge, reported fewer parent-rated behavioural problems at 5 years of age. The present study observed the children to 12 months only and cannot be regarded as a replication of that result.

Strengths of the study. Three features narrow the range of possible explanations for the observed differences. The groups were treated in the same department, by the same specialists, so the difference cannot be attributed to the provider of care, to the setting, or to the availability of rehabilitation as such; what the two periods did not share was the organisational route. Complete AIMS and HINE data were obtained for all 148 participants of both groups, without selective reporting of those who did well. And the two independent measures applied in the NICU and at first contact (GMA and HINE) did not differ statistically between the groups; this does not establish equivalence of baseline risk, but it narrows the range of explanations that can be proposed for the observed difference.

Limitations of the study. First, the design entails comparison with a historical control (the CG was formed from infants discharged in 2023), so the groups differ not only by the presence of structured coordination but also by calendar period, service availability and accumulated staff experience; these effects cannot be separated. Second, the model was implemented as a bundle –

organisational coordination, timeliness of referral and active function-based rehabilitation with parental involvement – therefore the individual contribution of each component cannot be determined from these data. Third, the groups were not fully balanced at baseline: the IG contained a significantly higher proportion of infants born before 28 weeks (29.8 % vs 10.9 %; p = 0.006), that is, infants at higher risk of motor impairment; this imbalance was not adjusted for in a multivariable model, and since other prognostic characteristics were not recorded, the direction of its net effect on the comparison cannot be established. Fourth, for the 15 CG infants for whom no referral was recorded the AIMS and HINE values were retrieved retrospectively from the medical records of the follow-up clinic, which introduces differential ascertainment between the groups; in addition, because no individual rehabilitation plans were drawn up in the CG, the content and intensity of the rehabilitation delivered in that group were not documented and could not be compared with those in the IG, even though both groups were treated in the same department by the same specialists. Fifth, the repeat assessment was anchored to corrected age and is therefore comparable between the groups, whereas the baseline assessment preceded the start of the course and was thus performed at different ages — on average some seven weeks earlier in the IG. The interval between the two assessments was correspondingly longer in the IG, which acts in favour of that group in the analysis of increments; since the exact individual corrected age on the day of examination was not recorded, this baseline difference could not be adjusted for. The actual number of delivered sessions, the duration of courses and adherence to the home programme were likewise not recorded, so equal intervention intensity could not be verified. Sixth, no primary outcome was prespecified and no sample size calculation was performed; the Holm-Bonferroni correction was applied post hoc, so the reported p values should be read as descriptive. Seventh, 'high parental compliance' was defined only by attendance at sessions, so that subgroup analysis (n = 41) is exploratory. Eighth, the subgroup with a gestational age below 28 weeks is too small for statistical comparison (25 vs 7) and is reported descriptively. Ninth, the study was conducted at a single institution and the assessment was not blinded, since the period to which an infant belonged was known to the specialists. Tenth, the HINE cut-off applied here was derived in a cohort of infants born preterm whose mean gestational age was 34.9 ± 2.4 weeks (range 25–36), whereas the mean gestational age in the present intervention group was 29.6 ± 3.2 weeks and almost one third of its infants were born before 28 weeks; reference values stratified by gestational age are not available for this instrument, so the same cut-off may not carry the same meaning in the two groups, in a direction that cannot be determined from these data. The development of gestational-age-stratified reference values for the HINE, and the separate validation of age-specific cut-offs for infants born very preterm, for whom published reference data are particularly sparse, and for late preterm infants, is therefore a necessary direction for further research.

Prospects for further research include the evaluation of long-term outcomes (2–5 years), a multicentre study of the reproducibility of the coordination protocol in an expanded sample with adequate statistical power, and the development of a standardised parent training module with verification of skill acquisition.

5. Conclusions

1. A structured protocol of coordination between the follow-up clinic and the rehabilitation department was associated with earlier initiation of early intervention: with baseline neurological profiles that did not differ statistically, timely referral to the MDRT rose from 46.9 % to 91.7 % ($p < 0.001$) and the interval from discharge to the first physical therapist appointment was reduced more than twofold ($p < 0.001$).

2. Outpatient active function-based rehabilitation without passive neurodevelopmental techniques was accompanied by improvement in neurological status and functional motor outcome: the increase in HINE scores in the intervention group almost doubled that in the control group ($p < 0.001$), although in both groups the mean score at the 6-month repeat assessment remained below the age-specific cut-off proposed for infants born preterm. The proportion of children with age-appropriate AIMS scores was higher in the intervention group at 6 months ($p = 0.010$) and at 12 months of corrected age ($p = 0.001$), with the effect size increasing with age.

3. Among the children who completed the 12-month observation, the rate of missed scheduled

visits in the intervention group was more than three times lower than in the control group ($p < 0.001$) and was lowest in the subgroup of families with high compliance at sessions. Overall retention was not assessed, since complete observation was an inclusion criterion.

4. Within the institution, the volume of rehabilitation services delivered almost doubled after the National Health Service licence was obtained, without any change in the methods of intervention. This is an activity indicator of a single centre, not a test of the reproducibility of the model; evaluation of a standardised protocol of interdepartmental interaction in other perinatal care institutions is therefore warranted. A causal conclusion requires a prospective study with a concurrent control group.

Conflicts of interests

The authors affirm that they have no conflicts of interest to disclose.

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