LATE-STAGE PHYSIOTHERAPY IN CHILDREN WITH DANDY-WALKER MALFORMATION: EVIDENCE FROM TWO PROSPECTIVE CASES WITH ATAXIA CONTROLS

ФІЗИЧНА ТЕРАПІЯ НА ПІЗНІХ СТАДІЯХ У ДІТЕЙ З МАЛЬФОРМАЦІЄЮ ДЕНДІ-ВОКЕРА: ДАНІ ДВОХ ПРОСПЕКТИВНИХ ВИПАДКІВ З КОНТРОЛЬНИМИ ГРУПАМИ АТАКСІЇ

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Abstracts

Purpose. This study aims to assess the impact of a comprehensive physical rehabilitation program on balance, motor function, and activities of daily living in children with Dandy-Walker malformation (DWM).

Methods. Two patients with DWM were included in this study. The prospective case study with controls was conducted involving two children with DWM and two age-matched controls with ataxia of other origins All participants were aged 11 to 14 years. Both patients underwent Ventriculoperitoneal shunting before the 12 months age. This study focuses on late-stage physiotherapy for DWM patients. Physical assessment of patients with DWM before the physiotherapy program revealed lack of balance, upper limb predominant muscle hypotonia and impaired motor control. Our approach for Dandy-Walker malformation is focused on mitigating symptoms and addressing functional impairments resulting from cerebellar dysfunction. The neurodevelopmental approach used emphasizes a functional progression of motor skills, mirroring typical development. Baseline and three-month follow-up assessments were performed using the Berg Balance Scale to evaluate static and dynamic balance. In this study, Electronic goniometer was used to measure the passive and active popliteal range of motion.

Findings. Results of assessment with the Berg Balance Scale reflect not only changes in the balance. Improvements of muscle tone in all 14 functional positions resulted in motor functional improvement of patients (sitting, standing, picking up objects and others). All additional motor maneuvers tested in patients showed improvement. The Berg Balance Scale (BBS) scores improved from 9 to 13 and 9 to 11 in the two DWM patients, respectively, indicating functional balance gains. The applied neurodevelopmental approach was adapted from established rehabilitation protocols used in children with Developmental Coordination Disorder (DCD).

Conclusions. Late-stage physiotherapy interventions for individuals with Dandy-Walker malformation should be personalized and adapted to the age of the patient, stage of recovery, and functional needs. This approach should not only focus on improving motor function but also on developing compensatory strategies and adaptive skills to enhance overall quality of life. The applied physiotherapy strategy for functional and balance recovery typically used for DCD patients showed high efficacy in the rehabilitation process of DWM patients. Further studies with a large sample size including the DWM patients can prove the high efficacy of this protocol.

Key words: Dandy-Walker malformation, physiotherapy, balance, functional improvement, muscle tone.

Мета. Це дослідження має на меті оцінити вплив комплексної програми фізичної реабілітації на рівновагу, рухові функції та повсякденну активність дітей із мальформацією Денді-Уокера (МДУ).

Методи. У цьому дослідженні брали участь двоє пацієнтів із МДУ. Проспективне клінічне дослідження з контрольною групою було проведено за участю двох дітей із МДУ та двох дітей відповідного віку з атаксією іншого походження. Всі учасники були віком від 11 до 14 років. Обидва пацієнти перенесли вентрикулоперитонеальне шунтування до 12-місячного віку. Це дослідження зосереджується на пізній стадії фізичної терапії для пацієнтів з МДУ. Фізична оцінка пацієнтів з МДУ перед початком програми фізичної терапії виявила порушення рівноваги, гіпотонію м'язів верхніх кінцівок та порушення моторного контролю. Наш підхід до лікування мальформації Денді-Уокера зосереджений на пом'якшенні симптомів та усуненні функціональних порушень, що виникають внаслідок дисфункції мозочка. Використаний підхід до нейророзвитку вказує на функціональному прогресуванні моторних навичок, що відображає типовий розвиток. Базова оцінка та оцінка через три місяці були проведені за допомогою шкали рівноваги Берга для оцінки статичної та динамічної рівноваги. У цьому дослідженні для вимірювання пасивного та активного діапазону руху підколінного суглоба використовувався електронний гоніометр.

Результати. Результати оцінки за шкалою рівноваги Берга відображають не тільки зміни в рівновазі. Поліпшення м'язового тонусу у всіх 14 функціональних положеннях призвело до поліпшення рухових функцій пацієнтів (сидіння, стояння, підняття предметів та ін.). Всі додаткові рухові маневри, які тестувалися у пацієнтів, показали поліпшення. Оцінки за шкалою Берга (BBS) покращилися з 9 до 13 та з 9 до 11 у двох пацієнтів з МДУ відповідно, що свідчить про функціональне поліпшення рівноваги. Застосований нейророзвивальний підхід був адаптований з усталених реабілітаційних протоколів, що використовуються у дітей з розладом координації розвитку (DCD).

Висновки. Реабілітаційні втручання на пізній стадії для осіб з мальформацією Денді-Уокера повинні бути індивідуалізованими та адаптованими до віку пацієнта, стадії відновлення та функціональних потреб. Цей підхід повинен бути спрямований не тільки на поліпшення моторної функції, але й на розвиток компенсаторних стратегій та адаптивних навичок для підвищення загальної якості життя. Застосована стратегія фізичної терапії для відновлення функцій і рівноваги, яка зазвичай використовується для пацієнтів з DCD, продемонструвала високу ефективність у процесі реабілітації пацієнтів з МДУ. Подальші дослідження з великою вибіркою, що включає пацієнтів з МДУ, можуть підтвердити високу ефективність цього протоколу.

Ключові слова: мальформація Денді-Уокера, фізична терапія, рівновага, функціональне поліпшення, м'язовий тонус.

Introduction. Dandy-Walker malformation (DWM) is a congenital neurological disorder characterized by structural abnormalities of the cerebellum and the surrounding lymphatic vessels. This rare condition affecting approximately 1 in 25.000 live births was named after Walter Dandy and Arthur Earl Walker, who first described this malformation in the early 20th century [1; 22; 24]. DWM was first described in 1914 by W. Dandy. Subsequently, in 1935, A.E. Walker proposed a surgical intervention for this congenital abnormality. Though the exact etiology of DWM remains elusive, both genetic and environmental factors potentially contribute to its emergence. Cerebellar development occurs during the first trimester of gestation [12]. Leading theories suggest that exposure to adverse factors during this critical period is strongly associated with disruptions in the formation of the cerebellum and rhombencephalon, with the absence of the IV ventricle opening and emergence of vascular tissue in the region [23].

DMW is characterized by the underdevelopment of the cerebellar vermis and the formation of a lymphatic cyst in the fourth ventricle, which impairs cerebrospinal fluid circulation within the cranial cavity, resulting in its accumulation.

Symptoms typically emerge during infancy; however, a delayed presentation is possible. In rare instances, the initial diagnosis may occur in adulthood. Clinical manifestations may include headache, facial palsy, hypertonia, and ataxia. Cognitive impairment and behavioral disturbances may also be observed in certain individuals.

A significant proportion of individuals with DWM may remain asymptomatic [4; 11; 17; 21]. The exact cause of DWM remains unknown. Congenital abnormalities typically arise during the first trimester of pregnancy, a critical period when the fetal organs are undergoing development. The formation of the brain's ventricular system occurs by approximately the sixth week of gestation Several genes, (including FOXC1, ZIC1, and ZIC4), have been implicated in the cause of DWM. Diagnosis is primarily achieved through neuroimaging techniques, with MRI serving as the standard for detailed examination of the brain. Prenatal diagnosis can also be conducted via ultrasonography; however, fetal brain anomalies typically cannot be detected prior to the 18th week of gestation, as the brain undergoes significant developmental maturation up to this point [21; 26].

Dandy-Walker syndrome is characterized by a distinct triad of clinical signs, which can be confirmed through instrumental diagnostic techniques. The triad integrates cerebellar hypoplasia (underdevelopment of the cerebellum, often affecting the vermis and hemispheres), cystic dilation of fourth ventricle (often extending into the posterior fossa) and hydrocephalus. In later stages, affected individuals may exhibit delays in neuropsychiatric and physical development, with varying degrees of cognitive and motor impairment.

Treatment for DWM patients aims to improve the overall functioning of patients and enhance quality of life through a multidisciplinary team. As the goal of patient management is to achieve normal development of children, the multidisciplinary strategy requires long-term follow-up of patients undergoing rehabilitation [10; 19].

The multidisciplinary approach integrates pediatric physiotherapeutic interventions. Psychotic symptoms, obsessive compulsive symptoms, mood symptoms, hyperactivity, and impulsive behavior associated with DWS have been documented in the literature [2; 8; 14]. Many reports have presented psychiatric treatment protocols and methods used to manage the mentioned symptoms [15; 16]. Motor symptoms in patients with DWM are usually not prioritized in the therapy plan. Before independently walking infants typically explore various mobility patterns, including crawling, creeping, and shuffling around on buttocks. Around 6-8 months, infants begin to attempt crawling. However, they may struggle with weight-bearing on their arms due to weak musculature. In children with Dandy-Walker malformation, this challenge is often exacerbated by muscle dystonia, which further hinders their ability to assume proper position. Around 10 months, most infants transition to crawling. Children with DWM often experience falls during this stage (typically face-forward) due to weak arm strength and impaired coordination, resulting in dysmetria and difficulty controlling their movements [12; 20].

Depending on the severity of the cerebellar malformation and associated neurological impairments, infants with DWM may present with developmental delays in the neonatal period [9]. For example, delays in motor skills such as sitting, crawling, standing, and walking may be observed at an older age. Additionally, children with DWM may exhibit difficulties with fine motor skills, including hand-to-mouth coordination, due to underlying cerebellar dysfunction and muscle tone abnormalities. Cerebellar hypoplasia and associated ataxia in DWM can significantly impair postural control and balance, leading to difficulties in maintaining upright positions and executing coordinated movements. Children with DWM may require support in achieving key developmental milestones, such as assuming a kneeling position, using furniture for support during standing, and attempting unilateral stance. Despite the complex motor and postural impairments associated with Dandy-Walker malformation, there is a notable absence of physiotherapy-focused clinical studies addressing functional rehabilitation in this population. This study aims to assess the impact of a comprehensive physical rehabilitation program on balance, motor function, and activities of daily living in children with Dandy-Walker malfunction.

Methods

Participants

This study is presented as a pilot investigation to explore the feasibility and effects of a structured physiotherapy protocol in children with Dandy-Walker malformation (DWM), given the rarity of the condition and limited clinical research on physiotherapeutic interventions in this population. The sample size of two DWM cases was selected to reflect the exploratory nature of the study. Two age- and sex-matched controls diagnosed with Developmental Coordination Disorder (DCD) were included for comparative purposes. These control participants were selected based on similarity in gross motor impairments, particularly balance deficits and coordination challenges, to ensure functional comparability at baseline. All diagnoses were confirmed by pediatric neurologists based on ICD-10 criteria and clinical neuroimaging. The study protocol was reviewed and approved by the Ethics Committee of the Armenian State Institute of Physical Culture and Sport (Protocol No. 07-2024, approved March 12, 2024). Written informed consent was obtained from the parents or legal guardians of all participants. All participants were aged 11 to 14 years. Both patients underwent Ventriculoperitoneal shunting before the 12 months age. This work presents the late stage physiotherapy for DWM patients. Physical assessment of patients with DWM before the physiotherapy program revealed lack of balance, upper limb predominant muscle hypotonia and impaired motor control. The control participants were selected according to the motor manifestations matching the symptoms of DWM patients.

Applied Physical Rehabilitation Strategies

Our approach for Dandy-Walker malformation (DWM) is focused on mitigating symptoms and addressing functional impairments resulting from cerebellar dysfunction. DWM primarily affects the cerebellum, leading to ataxia, motor incoordination, and delays in motor development. The implementation of neurodevelopmental therapy is crucial for optimizing the developmental trajectory of children with DWM, mitigating the impact of cerebellar dysfunction, and facilitating the acquisition of compensatory strategies.

The used neurodevelopmental approach emphasizes a functional progression of motor skills, mirroring typical development (Figure 1).

Approaches for the management of motor dysfunctions

- Transitioning from a supine to crawling position: From a prone position, the therapist initiates the movement by flexing one of the child's hips, shifting the pelvis weight to the contralateral side. The therapist then stabilizes the pelvis and shifts the weight towards the flexed hip. The free leg is flexed at the hip, and the therapist pulls the pelvis posteriorly to extend the trunk. With the shoulder girdle stabilized, the therapist shifts the child's weight to the opposite side, releasing one arm into extension. This process is repeated for the contralateral arm.
- If the child has proprioceptive difficulties that hinder their ability to maintain a crawling position, specific techniques are employed. By applying pressure along the joint axis towards a supporting surface, the child's body awareness and postural control are enhanced. This proprioceptive input helps the child to better perceive their body position in space and maintain the crawling posture.
- A foam roller can be placed under the child's abdomen while sustaining a crawl position, which in turn assists the child in leaning on their hands.
- Once the child can maintain a crawling position, the therapist can encourage the initiation of crawling by facilitating weight shifts and guiding the limbs.

Fig. 1. Strategies to recover motor function

Play-based therapy can be an effective tool for enhancing postural control and balance in children with DWM. By incorporating activities that require kneeling (such as building a pyramid or playing with toys), it can promote weight-bearing on the knees and maintain trunk stability.

In the kneeling position, the child can be encouraged to lift one leg and maintain balance. The therapist may provide support at the knee and hip joints to stabilize the raised leg. Once the child can maintain this position, they can be assisted in transitioning to a standing position by gently extending the raised leg.

To improve the ability to maintain a standing position, the child can be positioned against a wall with their buttocks and shoulders touching the surface, while their feet are slightly forward. The therapist can then gradually assist the child in leaning forward, reducing reliance on the wall for support.

From a seated position on a roller, the child can be encouraged to stand with or without support. The therapist can provide stability by supporting the child's trunk and gently guiding their knees into extension.

Assessment Tests Used

Baseline and three-month follow-up assessments were performed using the Berg Balance Scale to evaluate static and dynamic balance.

Berg Balance Scale

The Berg Balance Scale (BBS) is a widely used clinical tool designed to assess individuals with balance impairments [5; 27]. It consists of 14 tasks that evaluate a person's ability to perform common activities of daily living, such as sitting, standing, turning, and walking (Table 1). Each task is scored on a 5-point scale, (0–4, where 0 indicates the lowest level and 4 the highest) with a maximum total score of 56. A lower score indicates a higher risk of falls. It typically takes 15–20 minutes to administer. The BBS is a reliable and valid measure of balance function and has been used extensively in research and clinical practice to assess balance deficits, monitor treatment progress, and predict fall risk.

The fall risk is usually presented by three grades: first grade (0–20) with high risk of falling; second grade (21–40) with moderate risk of falling and the third grade (41–56) with low risk of falling.

Muscle Tone

In this study, Electronic goniometer, Baseline 12-1027 Absolute Axis digital goniometer (Baseline, Inc., New York, NY, USA, 2016) was

Table 1

Key Principles of the Adapted Neurodevelopmental Physiotherapy Protocol for Dandy-Walker Malformation

Therapeutic Focus	Description	Rationale
Developmental Sequencing	Interventions progressed from prone to crawling, kneeling, and supported standing	Mirrors typical motor development to stimulate neural pathways and promote functional milestones
Proprioceptive Stimulation	Joint compression, weight-bearing exercises, and sensory input through guided posture	Enhances body awareness and postural control, especially in cases of sensory integration deficits
Facilitated Transitions	Manual assistance in shifting weight and initiating movements (e.g., crawl, sit-to-stand)	Encourages motor planning and reduces fear of movement
Use of Assistive Tools	Foam rollers, wall support, and seated rolling devices to assist postural training	Provides stability and confidence during early motor attempts
Task-Oriented Play-Based Activities	Engaging tasks such as object manipulation in kneeling or crawling positions	Promotes motivation, trunk stability, and coordination through functional movement
Functional Movement Training	Emphasis on meaningful tasks like picking up objects, balance transitions, and early gait training	Supports autonomy and integration into daily activities

Table 2

Core Techniques Used in the Neurodevelopmental Protocol

Therapy Component	Technique Description	Therapeutic Goal
Crawling Techniques	– Hip flexion and pelvic shift to initiate movement – Shoulder girdle stabilization – Guided arm extension	Promote reciprocal limb use, motor coordination, and weight shifting
Proprioceptive Support	– Joint compression (along axis) during supported postures – Tactile feedback during crawl and kneel Foam roller under abdomen	Enhance body awareness, spatial orientation, and postural control
Kneeling to Standing Sequence	– Kneeling with weight-bearing on both knees – Assisted single-leg lift with manual stabilization – Guided transition to standing against wall or from a roller	Develop trunk stability, weight transfer ability, and progression to upright posture

used to measure the popliteal range of motion in passive, speed and active. In supine position ipsilateral hip and knee were flexed to 90° and the knee maximally passively extended to the point of mild resistance, active range of motion and range of motion with velocity were also measured in same positions [22]. To provide consistent rate and provide highly reliable measures, it was calculated as the mean of three trials. The ICC for this test was 0.999 [6].

Results. Results of assessment with the Berg Balance Scale reflect not only changes in the balance. Improvements of muscle tone across all 14 test positions resulted in motor functional improvement of patients (sitting, standing, picking up objects and others). All additional motor maneuvers tested in patients showed improvement (Table 4).

Given the significant cerebellar structural abnormalities in Dandy-Walker malfunction, children with this condition remain at a high risk of falls despite modest improvements in balance measures. To address these challenges and enhance quality of life, occupational therapists implemented a comprehensive intervention program focused on developing compensatory strategies and adaptive skills.

Although there is no universally established MCID for the Berg Balance Scale in children, especially in rare neurological conditions such as Dandy-Walker malformation, previous research suggests that a change of 4 to 6 points in BBS scores is generally considered clinically meaningful in pediatric populations with motor impairments, including cerebral palsy and developmental coordination disorder. In this study, both DWM patients demonstrated improvements of 2–4 points, approaching the lower threshold of clinically important change. These findings suggest that even modest gains may reflect meaningful functional improvements in children with significant cerebellar dysfunction, particularly when combined with qualitative gains in task performance and mobility.

Discussion. To date, no standardized physiotherapy protocol exists specifically for children with Dandy-Walker malformation, making the development and adaptation of targeted neurodevelopmental strategies an innovative and necessary contribution to clinical practice. Rehabilitation strategy in the late-stage physiotherapy and rehabilitation of patients with Dandy-Walker malformation, treated surgically in infancy, has to integrate mobility and gait training, strengthening and flexibility improvement, postural control and stability training, cognitive and neuroplasticity-based approaches and pain management techniques.

Mobility and gait training have to target gait re-education, use of assistive devices, proprioceptive and balance training. Many patients with DWM have abnormalities in their gait, often presenting with ataxia, unsteady walking, or compensatory movements. Late-stage physiotherapy aims to improve walking patterns by focusing on posture, stride length, step symmetry, and balance. Assistive devices such as walkers, canes, or orthotics may be introduced or adjusted to enhance mobility. The goal is to reduce reliance on these devices where possible

Table 3

Berg Balance Scale

Item	Description of the Task	Score 4 (Best)	Score 3	Score 2	Score 1	Score 0 (Worst)
1. Sitting to Standing	Stand up from sitting without using hands if possible	Stands without using hands and stabilizes independently	Stands independently using hands	Stands using hands after several tries	Needs minimal assist to stand	Needs moderate or maximal assist to stand
2. Standing Unsupported	Stand without support	Stands safely 2 min	Stands 2 min with supervision	Stands 30 sec unsupported	Needs several tries to stand 30 sec unsupported	Unable to stand 30 sec unsupported
3. Sitting Unsupported	Sit without back or arm support	Sits safely and securely 2 min	Sits 2 min under supervision	Sits 30 sec unsupported	Needs support to sit 2 min	Unable to sit unsupported 10 sec
4. Standing to Sitting	Sit down from standing	Sits safely with minimal use of hands	Controls descent using hands	Uses back of legs on chair	Sits independently but uncontrolled	Needs assistance to sit
5. Transfers	Transfer from one chair to another	Transfers safely with minor use of hands	Transfers safely with definite use of hands	Transfers with supervision/ verbal cues	Needs one person assist	Needs two persons assist
6. Standing Unsupported, Eyes Closed	Stand with eyes closed	Stands 10 sec safely	Stands 10 sec with supervision	Stands 3 sec	Needs help to stand	Unable to keep eyes closed standing
7. Standing Unsupported, Feet Together	Stand with feet together	Places feet together and stands 1 min safely	Places feet together and stands 1 min with supervision	Places feet together and stands 30 sec	Needs help to attain position but stands 15 sec	Needs help to attain position and cannot stand 15 sec
8. Reaching Forward While Standing	Reach forward with outstretched arm	Reaches >25 cm (10 in) confidently	Reaches 12–25 cm (5–10 in)	Reaches 5–12 cm (2–5 in)	Reaches <5 cm (<2 in)	Loses balance/ requires support
9. Pick Up Object from Floor	Pick up object from floor while standing	Picks up object safely and easily	Picks up object but needs supervision	Unable to pick up but reaches near object	Needs help to keep balance while reaching	Unable to try or needs assistance
10. Turning to Look Behind Over Shoulders	Turn to look behind left and right	Looks behind from both sides weight-shifting well	Looks behind one side only	Turns sideways only but maintains balance	Needs supervision	Needs assistance
11. Turn 360 Degrees	Turn in a full circle	Turns safely in 4 sec or less	Turns safely one direction only in 4 sec or less	Turns slowly but safely	Needs supervision/ verbal cueing	Needs assistance
12. Place Alternate Foot on Step/ Stool	Place foot alternately on step (8 reps)	Completes 8 steps safely in 20 sec	Completes 8 steps in >20 sec	Completes 4 steps without aid	Completes >2 steps with minimal assist	Needs assistance
13. Standing Unsupported, One Foot in Front (Tandem)	Place one foot directly in front of the other	Can place foot directly in front and hold 30 sec safely	Can step ahead and hold 30 sec	Can step ahead and hold 15 sec	Needs help to step but can hold 15 sec	Loses balance while stepping or cannot hold 15 sec
14. Standing on One Leg	Stand on one leg	Lifts leg independently and holds > 10 sec	Lifts leg and holds 5–10 sec	Lifts leg and holds ≥3 sec	Tries to lift leg but unable to hold 3 sec	Unable to try or needs assistance

Table 4

Combined Berg Balance Scale Scores for Dandy–Walker and Ataxia Patients

	DWM patients				Ataxia Patients			
Description	**I Initial**	**I Final**	**II Initial**	**II Final**	**I Initial**	**I Final**	**II Initial**	**II Final**
Sitting to Standing	4	4	4	4	4	4	4	4
Standing Unsupported	2	3	2	3	2	3	2	3
Sitting Unsupported	1	1	1	1	2	3	1	1
Standing to Sitting	0	1	0	0	3	4	0	1
Transfers	1	2	1	1	3	4	1	2
Standing Unsupported, Eyes Closed	0	0	0	0	2	3	0	0
Standing Unsupported, Feet Together	0	0	0	0	0	0	0	0
Reaching Forward While Standing	0	0	0	0	3	4	0	0
Pick Up Object from Floor	0	0	0	0	2	3	0	0
Turning to Look Behind Over Shoulders	1	2	1	2	2	2	1	2
Turn 360 Degrees	0	0	0	0	3	4	0	0
Place Alternate Foot on Step/Stool	0	0	0	0	0	2	0	0
Standing Unsupported, One Foot in Front (Tandem)	0	0	0	0	0	0	0	0
Standing on One Leg	0	0	0	0	0	1	0	0
Total	9	13	9	11	26	36	9	13

Table 5

Functional Performance of Two Patients with Dandy-Walker Syndrome Before and After Physiotherapy

Function	**(Dandy Walker Syndrome) Patient 1**	**(Dandy Walker Syndrome) Patient 2**		
	Before	**After**	**Before**	**After**
Maintaining a kneeled position	0	50 sec.	2 sec.	3-4 mins.
Crawling	3 meter	5 meter	1 meter	3 meter
Standing up	1sec.	10 sec.	1 sec.	15 sec.
Walking with parallel bars	1	5	–	–
Wheelchair	0	30 meter	0	15 meter
Walking with aid	5	18		–

while ensuring safe mobility. These exercises help improve body awareness and control, which is vital for reducing fall risk and enhancing overall coordination. Activities such as standing on uneven surfaces or practicing walking with eyes closed may be part of this [7; 25].

Parallelly we have improved the overall motor function by maximizing functional independence, improving mobility and reducing dependence on assistive devices, addressing secondary complications, improving pain management and ensuring the long-term physical health maintenance. For patients with DWM, late-stage rehabilitation focuses on helping individuals achieve as much independence as possible. This may include strategies for self-care, mobility, and handling daily activities, whether the patient is a child, adolescent, or adult. Goal-setting in this stage is often oriented toward the patient's specific life context (e.g.,

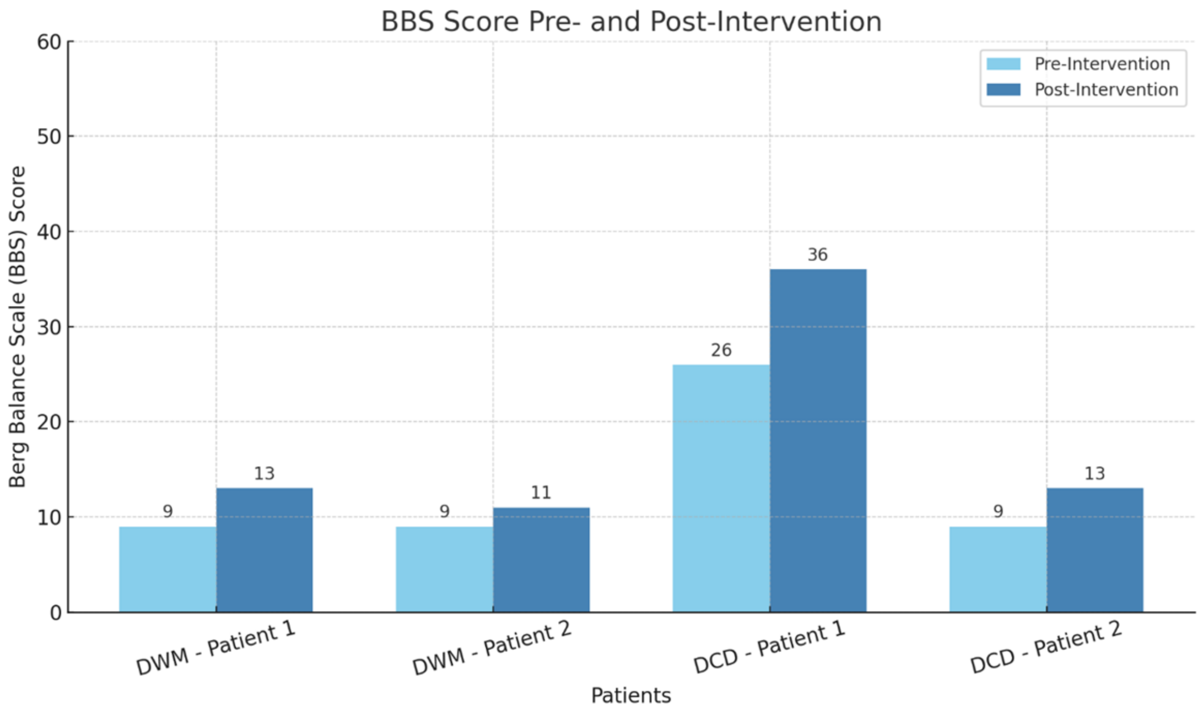

Fig. 2. Bar graph illustrating the Berg Balance Scale (BBS) scores pre- and post-intervention for each participant. It shows the functional balance improvements across both DWM and DCD cases

school, work, social integration). While assistive devices may have been necessary early in the rehabilitation process, a critical goal in late-stage physiotherapy is improving mobility [3]. This can involve enhancing gait efficiency, posture control, and the use of assistive devices only when necessary. As patients age, there is a risk of secondary complications such as joint deformities, muscle contractures, and osteoporosis due to immobility or spasticity. Physiotherapy helps mitigate these risks through tailored exercises, stretching routines, and weight-bearing activities. Many individuals with DWM may experience chronic pain due to neurological deficits, spasticity, or post-surgical issues. Late-stage rehabilitation includes pain management strategies that improve mobility and overall comfort. Encouraging lifelong physical activity is important for maintaining overall health, cardiovascular fitness, and muscle strength, as well as for preventing long-term musculoskeletal issues like contractures, scoliosis, or hip dislocation [13].

Although physiotherapy primarily addresses physical aspects, coordination with occupational therapists, psychologists, and neuropsychologists is essential for addressing cognitive and social impairments, promoting self-confidence, and facilitating better communication and social integration.

In our program the physiotherapy program was concentrated on strength training, stretching and range of motion exercises, functional movement training, postural control and stability, as well as cognitive rehabilitation. Chronic muscle weakness is common in patients with DWM. Physiotherapists use resistance training, bodyweight exercises, or functional movement tasks to strengthen muscles, focusing on the core, lower limbs, and upper limbs. Stretching and joint mobilization techniques help prevent contractures and improve joint flexibility. This is particularly important for patients with spasticity, a common condition in DWM, which can lead to stiff joints and reduced mobility. To ensure that the patient can independently perform daily activities such as sitting, standing, walking, and transferring, physiotherapists may use functional movement exercises that simulate real-life tasks. Many individuals with DWM exhibit poor postural control due to cerebellar involvement. Strengthening exercises aimed at the trunk, shoulders, and pelvis can significantly improve postural stability. Postural control exercises can also reduce the risk of scoliosis or other musculoskeletal problems. Key muscles for trunk stability and balance are targeted with exercises such as bridging, planking, and seated balance activities. Engaging in tasks that require maintaining balance during movement (e.g., walking while carrying objects or changing direction) enhances dynamic postural control [18].

For patients experiencing cognitive difficulties, physiotherapists work in collaboration with neuropsychologists or occupational therapists to incorporate strategies that help with attention, memory, and executive function during physical tasks. Brain-based therapies that challenge the cerebellum's coordination and motor learning are key. Repetitive exercises that require attention to detail or multi-tasking can promote motor recovery, tapping into neuroplasticity for better outcomes.

For the effective pain management strategy heat, cold, and electrical stimulation (TENS) have shown higher efficacy in combination with exercise therapy reducing pain and improving circulation.

Hydrotherapy is method of choice used in late-stage rehabilitation to provide a supportive environment for exercise, especially for patients with severe balance difficulties. The buoyancy of water reduces the risk of falls, and water resistance helps build strength and endurance without placing undue stress on joints.

Rehabilitation does not end after a few months or years; ongoing management is essential. Physiotherapists must monitor the progress in patients and adapt interventions as the individual grows or faces new challenges. The rehabilitation team has to conduct regular evaluations to identify new motor, cognitive, or psychological challenges. Providing families with strategies for managing day-to-day care needs, including mobility aids, home modifications, and safety protocols is essential. The applied physiotherapy strategy resulted in functional and balance improvement similarly in patients with DCD (the controls) and DWM (Tables 2–5) indicating the efficacy of this structured physical therapy intervention for children with DWM.

Conclusions. This pilot study highlights the feasibility and potential effectiveness of a structured, neurodevelopmentally informed physiotherapy protocol for children with Dandy-Walker malformation. The approach, originally adapted from rehabilitation strategies used in Developmental Coordination Disorder, demonstrated measurable improvements in balance and functional mobility. Given the promising outcomes, this physiotherapy model holds potential for replication in specialized pediatric neurorehabilitation centers, where individualized, function-oriented interventions are essential. Limitations of the present study include the small sample size and short follow-up period. Future multicenter trials with larger cohorts and extended observation are warranted to validate the efficacy and generalizability of this rehabilitation strategy.

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