



# Functional Gains Through Individualized Strength Training in a Pediatric with Duchenne Muscular Dystrophy

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## ABSTRACT

### INTRODUCTION AND PURPOSE

Duchenne muscular dystrophy (DMD) is one of the most severe forms of inherited muscular dystrophy. It is a progressive genetic disorder and the most common neuromuscular hereditary disease, primarily affecting boys. The disorder leads to progressive muscle weakness and typically presents in early childhood. This case report presents the clinical outcomes of an individualized, low-resistance strength exercise intervention in a 5-year-old pediatric patient diagnosed with DMD. The objective is to evaluate the safety, feasibility, and potential effects of the intervention on muscle strength, endurance, functional performance, and quality of life. Through an individualized and structured physical therapy program, we aim to illustrate that individualized strength training can be a beneficial component in the multidisciplinary care of children with DMD.

### PRESENTATION

The patient is a 5-year-old male who presented to the physical therapy clinic with the assistance of his mother. He exhibited a waddling gait (difficulty in walking) and had a diagnosis of DMD, confirmed 3 years ago. His primary impairments included difficulty in walking and rolling, with increasing limitations in balance and mobility, as indicated by functional assessments. Pain was scored 8/10 on the Visual Analog Scale, impacting his daily living. Clinical assessment revealed lumbar hyperlordosis and anterior pelvic tilt. A surgical scar was observed in the left thigh. Palpation indicated hypertrophy of the left quadriceps muscle. Passive Range of Motion (ROM) in both hip and knee flexion was limited bilaterally due to pain at the end range. The patient suffers from general muscle weakness, particularly in both hip and knee muscles.

### DISCUSSION

DMD is a progressive neuromuscular disorder caused by mutations in the dystrophin gene, leading to muscle weakness and gradual loss of function. Physical therapy plays a critical role in managing the mechanical and functional impairments associated with DMD. A multimodal approach that combines manual therapy, therapeutic exercises, postural training, and pain management techniques has been shown to be effective in reducing pain and improving function. This case report demonstrates that an individualized, low-resistance strength training program can lead to significant clinical outcomes in a pediatric patient with DMD.

### CONCLUSION

An individualized, low-resistance strength training program, designed according to the patient's functional limitations and abilities, can help reduce pain, enhance mobility, and improve muscle strength, thus improving overall functional outcomes.

**Keywords:** Duchenne muscular dystrophy, Individualized low-resistance strength training, Pediatric isometric exercise intervention, Functional mobility assessment, Gait rehabilitation outcomes

### Introduction

Muscular dystrophy refers to a group of hereditary diseases characterized by generalized progressive degeneration of skeletal muscle.<sup>1</sup> These conditions result from genetic mutations that interfere with the production of essential muscle proteins, often due to deficient or absent glycoproteins in the muscle cell membrane.<sup>2</sup> Muscular dystrophy conditions are a type of myopathy, which involves diseases affecting skeletal muscles.<sup>3</sup> Muscular dystrophy has its own pattern of inheritance, onset, severity, and the rate at which the muscle is lost.<sup>3</sup> Over time, affected muscles shrink and become weakened, impairing the individual's ability to walk and perform daily activities.<sup>3</sup> Some forms of muscular dystrophy appear at birth or develop during childhood or later during adulthood. The clinical presentation varies based on the specific gene mutation involved.<sup>1</sup> DMD affects males more than females, with a rate of 3.6/100,000 individuals.<sup>1</sup>

Muscular dystrophy most often results from an absent or defective glycoprotein in the membrane of the muscle.<sup>1</sup> Each type of muscular dystrophy is caused by specific mutations and deletions, leading to various metabolic and enzymatic defects that affect the muscle protein function.<sup>1</sup> The dystrophin gene, the largest gene in the human genome with 79 exons, is often subject to a high rate of spontaneous mutations because of its enormous size, resulting in Duchenne muscular dystrophy (DMD).<sup>2</sup>

Most mutations are inherited, although in some cases they occur spontaneously, which can then be inherited by an affected person's offspring.<sup>2</sup>

There are three main inheritance patterns of DMD. The first is autosomal dominant inheritance, where the mutation is inherited from a parent with the disease, causing DMD.<sup>2</sup> Second is the autosomal recessive inheritance, which requires that matching genes must include a mutation to cause the disease.<sup>1</sup> Third and the last is X-linked recessive, where the genetic mutation is passed from one generation to the next through the X chromosome, most commonly affecting males.<sup>3</sup> Physical therapists play a crucial role in helping individuals with DMD maintain function and mobility for as long as possible.<sup>2</sup> They also support their families in managing complications such as muscle weakness, joint stiffness, and contractures.<sup>1</sup> Physical therapy can help keep children with DMD active and mobile as long as possible.<sup>4</sup>

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Physical therapists monitor the child's posture in standing, sitting, and lying positions.<sup>4</sup> They provide guidance and instructions to parents on how to support proper positioning using pillows and splints to help the child maintain optimal postural alignment.<sup>4</sup>

They also play a key role in advising parents on the need for orthotics, such as Knee-Ankle-Foot Orthosis (KAFO) or Ankle-Foot Orthosis (AFO).<sup>5</sup> Also, in choosing mobility aids and equipment a child may need.<sup>4</sup> A night splint may be recommended to maintain the child's posture over a long period of time.<sup>5</sup>

Each physical therapist's treatment plan is designed based on the child's age, the specific type of muscular dystrophy, and the progression of symptoms to meet the child's unique needs.<sup>5</sup>

Strength training is commonly used to improve muscle endurance and optimize muscle function in individuals with muscle disease.<sup>6</sup>

However, there is still uncertainty regarding the most effective intensity, frequency, and type of exercise for patients with DMD.<sup>6</sup> Submaximal regular exercise may help prevent secondary muscle atrophy by maintaining muscular strength.<sup>6</sup> Isometric exercises, where force is generated without a change in joint angle or muscle length, have been suggested as a potentially safe mode of exercise for patients with DMD.<sup>5</sup> However, high resistance eccentric exercise, where the muscle is both lengthened and activated, may lead to muscle damage and should be avoided in this population.<sup>6</sup>

## Methods

This case report was documented and conducted in accordance with the CAse REport guidelines, ensuring standardized and comprehensive clinical reporting.

## Timeline

See Table 1

## Case Presentation

The patient is a 5-year-old male who presented to the physical therapy clinic with a history of progressive musculoskeletal symptoms that began 3 years ago. Initially, he experienced generalized body pain and developed a waddling gait that gradually worsened, leading him to crawl and, subsequently, an inability to rise from bed independently. A full-body Magnetic Resonance Imaging (MRI) was performed as part of the initial medical investigation, which revealed severe

bone inflammation. This is followed by a bone biopsy from the right femur that confirmed nonspecific inflammation. A definitive diagnosis of DMD was later established by a physician. At present, the patient experiences localized, moderate pain in the right hip, associated with femoral head degeneration. This has resulted in functional limitations, including difficulty with running, walking, rolling in bed, and performing activities of daily living (ADLs), such as eating, and instrumental activities of daily living (IADLs), such as putting on shoes. He also presents with reduced mobility and stiffness. His surgical history includes a prior hernia repair. There is no significant family history. The patient's current medication is Enbrel, and every 2 weeks immunoglobulin injections. For the past 1 year, the patient has been receiving physical therapy, 2 sessions per week, focusing on pain management, strengthening of upper and lower limb muscles, functional mobility training, and core stabilization.

## Observation, Evaluation, and Examination

### General Morphology

The patient presented to the center with the assistance of his mother, exhibiting a waddling gait and difficulty walking. Clinical observation revealed that the right leg was positioned in abduction and external rotation.

### Morphostatic Assessment

Anterior view: the upper limbs and the external projections appear symmetrical. The clavicles and shoulders are aligned at the same level. The head is centralized. The right Anterior Superior Iliac Spine (ASIS) is higher than the left. A valgus deformity is observed in the right knee, along with internal rotation of the right hip coxa.

Posterior view: the trunk reveals lumbar hyperlordosis. The scapulae are aligned. An elevation in the right pelvic crest is noted. The right popliteal fossa, as well as both external and internal malleoli, are positioned higher than those on the left side. The Achilles tendon appears centralized.

Lateral view: in the trunk, there is a lumbar hyperlordosis. At the level of the lower limbs, there is an anterior pelvis tilt.

### Pain Assessment

1. Date of onset of pain: 12/3/2024
2. Quality: nociceptive
3. Period of pain: chronic
4. Modalities of appearance: gradually
5. Location: currently, the pain persists in the right femur laterally postbiopsy
6. Frequency: periodic
7. Depth of pain: deep
8. Description of pain: nagging
9. Time(day/night): during the night
10. Triggering factors: walking, running, jumping, rolling over the bed
11. Aggravating factors: walking, running, jumping, rolling over the bed
12. Relieving factors: pain killers (Panadol), rest

**Table 1 | Chronological timeline of case events**

Date	Event
March 2022	Onset of symptoms: general pain and waddling gait
January 2023	MRI and bone biopsy revealed nonspecific bone inflammation
March 2023	Definitive diagnosis of DMD confirmed
July 2023	Initiation of physical therapy, two sessions per week
March 2024	Onset of localized right femur pain postbiopsy
July 2025	Current clinical reassessment and functional reevaluation

**Table 2 | Trophic assessment**

	Cutaneous	Muscular	Bone						
Observation	<ul style="list-style-type: none"> <li>Scar is located laterally at the right thigh due to the biopsy.</li> <li>Aspect of the skin due to scar: stretch mark.</li> </ul>	<ul style="list-style-type: none"> <li>Right quadriceps: hypertrophy</li> <li>Left quadriceps: atrophy</li> <li>R/L calf: atrophy</li> </ul>	<ul style="list-style-type: none"> <li>Right knee valgus</li> <li>Right ASIS, PSIS, and popliteal fossa higher than the left ASIS.</li> </ul>						
Palpation	<ul style="list-style-type: none"> <li>Skin sensitivity: normal sensibility.</li> </ul>	<ul style="list-style-type: none"> <li>Right quadriceps: hard</li> <li>Left quadriceps: soft</li> </ul>	<ul style="list-style-type: none"> <li>The greater trochanter of the right hip is located more superiorly than the left one.</li> </ul>						
Mobilization	<ul style="list-style-type: none"> <li>In comparison to the healthy side the extensibility and mobility of the skin are less than the unaffected side.</li> </ul>	<ul style="list-style-type: none"> <li>Right quadriceps: hypomobility</li> <li>Left quadriceps: normal mobility.</li> </ul>							
Measurement	<ul style="list-style-type: none"> <li>Scar length: 6.5 cm</li> </ul>					Region	Right	Left	Difference
		Region	Right	Left	Difference	thigh	26	24	22
		Quad (rectus femoris/ vastus lateralis/vastus medialis)				Leg	24	22	22
		Calf	16 cm	16 cm	0	Height of Lower Limb (LL)	50	46	
						(Tape measurement)	(Tape measurement)		

**Table 3 | ROM measurement**

Joints	Movement	Normal Range Measurement		Active	Passive	Difference
		Tape Measure	Goniometer			
Hip	Flexion	-	120°	115	116	1
	Extension	-	30°	25	28	3
	Abduction	-	-	28	30	2
	Adduction	-	30°	30	30	0
	Internal rotation	-	45°	42	43	1
	External rotation	-	45°	42	43	1
Knee	Flexion	-	135°	120	125	5
	Extension	-	0°	0	0	0
	Rotation	-	40°–58°	45	46	1

**Table 4 | Muscle testing**

	Muscle	Movement	Side	Grade
Knee	Quadriceps	Knee ext	R/L	3–/5
	Hamstring	Knee flex	R/L	3–/5
Hip	Iliopsoas	Flex of thigh	R/L	3–/5
	Sartorius	Flex ABD ER	R/L	3/5
	Tensor Fasciae Latae (TFL)	Flex ABD	R/L	3/5
	Gluteus medius	Abduction (ABD)	R/L	3+/5
	Gluteus minimus	Internal Rotation (IR)	R/L	3+/5
	Gluteus maximus	Ext	R/L	3/5
	External rotators	External Rotation (ER)	R/L	4/5
Adductors	Adduction (ADD)	R/L	3/5	

13. Impacts on ADL/mood/sleep: loss of mobility since he cannot run, walk, or jump normally without pain. He has a sleep disturbance due to pain

14. Intensity: 8/10

**Conclusion**

The patient presents with inflammatory nociceptive pain, currently localized at the right femoral region, associated with femoral head degeneration and post-biopsy changes. The pain is aggravated by weight-bearing activities such as walking, running, jumping, and prolonged standing. Improved with analgesic medication (Panadol), pain was scored 8/10 according to the Wong-Baker FACES Pain Rating Scale (FACES) Pain Rating Scale.

**Trophic Assessment**

See Table 2

**Conclusion**

A scar measuring 6.5 cm was observed and measured. The patient has a hypertrophy (increase in the muscle volume) of the right quadriceps muscle, which appears hard on palpation. In contrast, the left quadriceps muscle is atrophic (decrease in the muscle volume) and is soft on palpation, and shows normal mobility.

**Articular Assessment**

- Observation:
  - Right knee valgus

- Right ASIS/Posterior Superior Iliac Spine (PSIS) higher than left
- Right popliteal fossa higher than left
- Right internal/external malleoli higher than the left

- Passive range of motion:
  - Passive hip and knee flexion were limited due to pain (soft end-feel).

- Palpation:
  - Right PSIS/ASIS more elevated than the left.
  - Measurement (Table 3):

**Conclusion**

Moderate pain during passive knee flexion and hip flexion, which limits him to do full flexion. The Passive Range of Motion (PROM) is soft end-feel.

**Muscle Testing**

See Table 4

**Conclusion**

The patient suffers from generalized muscle weakness in the hip and right knee muscles. The weakness was especially prominent in the quadriceps, hamstrings, iliopsoas, and adductor muscles. The patient does them against gravity, but he cannot do all repetitions due to pain and early fatigue.

**Functional Assessment**

**Qualitative:**

- Lower extremity:
  - Walk: waddling walk
  - Run: not able
  - Jump: not able
  - Go downstairs: able with assistance

- Go upstairs: able with assistance
- Return: able with slight limitation

**Quantitative**

- Tinetti balance assessment tool with a score = 9/28
- Lower extremity functional index (LEFI) with a score = 61/80
- Barthel index with a score: 65/100

## TINETTI BALANCE ASSESSMENT TOOL

*Tinetti ME, Williams TF, Mayewski R, Fall Risk Index for elderly patients based on number of chronic disabilities. Am J Med 1986;80:429-434*

PATIENTS NAME \_\_\_\_\_ D.o.b. \_\_\_\_\_ Ward \_\_\_\_\_

**BALANCE SECTION**

Patient is seated in hard, armless chair;

		Date	
Sitting Balance	Leans or slides in chair	= 0	
	Steady, safe	= 1	
Rises from chair	Unable to without help	= 0	
	Able, uses arms to help	= 1	
	Able without use of arms	= 2	
Attempts to rise	Unable to without help	= 0	
	Able, requires > 1 attempt	= 1	
	Able to rise, 1 attempt	= 2	
Immediate standing Balance (first 5 seconds)	Unsteady (stagger, moves feet, trunk sway)	= 0	
	Steady but uses walker or other support	= 1	
	Steady without walker or other support	= 2	
Standing balance	Unsteady	= 0	
	Steady but wide stance and uses support	= 1	
	Narrow stance without support	= 2	
Nudged	Begins to fall	= 0	
	Stagger, grabs, catches self	= 1	
	Steady	= 2	
Eyes closed	Unsteady	= 0	
	Steady	= 1	
Turning 360 degrees	Discontinuous steps	= 0	
	Continuous	= 1	
	Unsteady (grabs, stagger)	= 0	
	Steady	= 1	
Sitting down	Unsafe (misjudged distance, falls into chair)	= 0	
	Uses arms or not a smooth motion	= 1	
	Safe, smooth motion	= 2	
<b>Balance score</b>		<b>5 /16</b>	/16

P.T.O.

Fig 1 | Tinetti Balance Assessment Tool (Balance section)

## TINETTI BALANCE ASSESSMENT TOOL

### GAIT SECTION

Patient stands with therapist, walks across room (+/- aids), first at usual pace, then at rapid pace.

		Date		
Indication of gait (Immediately after told to 'go'.)	Any hesitancy or multiple attempts No hesitancy	= 0 = 1		
Step length and height	Step to Step through R Step through L	= 0 = 1 = 1		
Foot clearance	Foot drop L foot clears floor R foot clears floor	= 0 = 1 = 1		
Step symmetry	Right and left step length not equal Right and left step length appear equal	= 0 = 1	= 0	
Step continuity	Stopping or discontinuity between steps Steps appear continuous	= 0 = 1	= 0	
Path	Marked deviation Mild/moderate deviation or uses w. aid Straight without w. aid	= 0 = 1 = 2		
Trunk	Marked sway or uses w. aid No sway but flex. knees or back or uses arms for stability No sway, flex., use of arms or w. aid	= 0 = 1 = 2		
Walking time	Heels apart Heels almost touching while walking	= 0 = 1		
	<b>Gait score</b>		<b>4 /12</b>	<b>/12</b>
	<b>Balance score carried forward</b>		<b>/16</b>	<b>/16</b>
	<b>Total Score = Balance + Gait score</b>		<b>9/28</b>	<b>/28</b>

### Risk Indicators:

Tinetti Tool Score	Risk of Falls
≤18	High
19-23	Moderate
≥24	Low

Fig 2 | Tinetti Balance Assessment Tool (Gait section)

**THE  
BARTHEL  
INDEX**

**Patient Name:** \_\_\_\_\_

**Rater Name:** \_\_\_\_\_

**Date:** \_\_\_\_\_

Activity	Score
<p><b>FEEDING</b>                      0 = unable                      5 = needs help cutting, spreading butter, etc., or requires modified diet                      10 = independent</p>	_____
<p><b>BATHING</b>                      0 = dependent                      5 = independent (or in shower)</p>	_____
<p><b>GROOMING</b>                      0 = needs to help with personal care                      5 = independent face/hair/teeth/shaving (implements provided)</p>	_____
<p><b>DRESSING</b>                      0 = dependent                      5 = needs help but can do about half unaided                      10 = independent (including buttons, zips, laces, etc.)</p>	_____
<p><b>BOWELS</b>                      0 = incontinent (or needs to be given enemas)                      5 = occasional accident                      10 = continent</p>	_____
<p><b>BLADDER</b>                      0 = incontinent, or catheterized and unable to manage alone                      5 = occasional accident                      10 = continent</p>	_____
<p><b>TOILET USE</b>                      0 = dependent                      5 = needs some help, but can do something alone                      10 = independent (on and off, dressing, wiping)</p>	_____
<p><b>TRANSFERS (BED TO CHAIR AND BACK)</b>                      0 = unable, no sitting balance                      5 = major help (one or two people, physical), can sit                      10 = minor help (verbal or physical)                      15 = independent</p>	_____
<p><b>MOBILITY (ON LEVEL SURFACES)</b>                      0 = immobile or &lt; 50 yards                      5 = wheelchair independent, including corners, &gt; 50 yards                      10 = walks with help of one person (verbal or physical) &gt; 50 yards                      15 = independent (but may use any aid; for example, stick) &gt; 50 yards</p>	_____
<p><b>STAIRS</b>                      0 = unable                      5 = needs help (verbal, physical, carrying aid)                      10 = independent</p>	_____

**TOTAL (0-100): 65/100**

**Conclusion: moderate dependency**

*Provided by the Internet Stroke Center — www.strokecenter.org*

Fig 3 | The Barthel Index

Lower Extremity Functional Scale (LEFS)

## Instructions

We are interested in knowing whether you are having any difficulty at all with the activities listed below **because of your lower limb problem** for which you are currently seeking attention. Please provide an answer for **each** activity.

**Today, do you or would you have any difficulty at all with:**

Activities	Extreme difficulty or unable to perform activity	Quite a bit of difficulty	Moderate difficulty	A little bit of difficulty	No difficulty
1. Any of your usual work, housework or school activities.	0	1	2	3	4
2. Your usual hobbies, recreational or sporting activities.	0	1	2	3	4
3. Getting into or out of the bath.	0	1	2	3	4
4. Walking between rooms.	0	1	2	3	4
5. Putting on your shoes or socks.	0	1	2	3	4
6. Squatting.	0	1	2	3	4
7. Lifting an object, like a bag of groceries from the floor.	0	1	2	3	4
8. Performing light activities around your home.	0	1	2	3	4
9. Performing heavy activities around your home.	0	1	2	3	4
10. Getting into or out of a car.	0	1	2	3	4
11. Walking 2 blocks.	0	1	2	3	4
12. Walking a mile.	0	1	2	3	4
13. Going up or down 10 stairs (about 1 flight of stairs).	0	1	2	3	4
14. Standing for 1 hour.	0	1	2	3	4
15. Sitting for 1 hour.	0	1	2	3	4
16. Running on even ground.	0	1	2	3	4
17. Running on uneven ground.	0	1	2	3	4
18. Making sharp turns while running fast.	0	1	2	3	4
19. Hopping.	0	1	2	3	4
20. Rolling over in bed.	0	1	2	3	4
<b>Column Totals:</b>	0	1	2	3	4

Score: 61/80 Page 2

**Conclusion:** The lower the score the greater the disability (moderate disability).

Fig 4 | The Barthel Index – Instructions

### Conclusion

The LFEI indicates that the patient has moderate disability, thus he cannot cope with most daily living activities. The Tinetti Balance and Gait Scale shows that the patient has a high risk of falls (Figures 1 and 2). The Berg Balance Scale indicates that the patient is moderately dependent during functional balance tasks (Figures 3 and 4).

### Outcome Measures Used

- **Wong-Baker FACES Pain Rating Scale:** to assess the intensity of the child's pain (scored 8/10 at baseline)
- **Tinetti Performance-Oriented Mobility Assessment:** to assess gait and balance (score: 9/28)
- **LEFI:** to evaluate lower limb function and limitations (score: 61/80)
- **Barthel index:** to assess performance in daily activities (score: 65/100)

These tools were selected based on age and clinical relevance to DMD. Assessments were conducted at baseline and at periodic follow-ups to guide treatment modifications.

### Gait Analysis

Due to lower limb pain and muscle weakness, the patient has a Duchenne (waddling) gait pattern. While walking, the shoulders and arms are held back awkwardly, a sway back posture is observed, and the abdomen protrudes due to weak muscles. The knees hyperextended, bent back to shift the weight.

### Stance Phase

- Heel strike: normal
- Mid stance: the right hip is externally rotated and abducted, which moves from 10° of flexion into extension. However, the knee does not reach full flexion, as the patient compensates to stabilize the limb due to quadriceps weakness. The ankle is supinated, dorsiflexed, and abducted.
- Heel off: the patient bypasses normal hip hyperextension (10°–15°) and shifts directly into hip flexion, making a compensation by elevating the right hip. The right knee is flexed, and the ankle is supinated and plantarflexed.
- Toe off: by the compensation of the right hip elevation, the patient performs premature ankle plantar flexion, causing the entire foot to lift off the ground.

### Swing Phase

- Early swing: the patient does not achieve 10° of hip extension, instead shifting directly into hip flexion. Excessive ankle plantarflexion was observed (this was due to compensatory movement in the flexors and abductors of the hip, in order to aid floor clearance).
- Midswing: normal

### Conclusion

The patient presents with a waddling gait pattern characterized by pelvic elevation, lower limb abduction,

Table 5 | Problem list

Impairment	Functional Limitation
Moderate pain	Unable to walk
Muscle weakness	Difficulty in walking and running
Balance deficit	Standing on one leg/jumping

and external rotation on the left side. These compensations are more prominent during the stance phase, due to weakness and pain, especially in the hip and thigh muscles.

### Problem List

See Table 5

### Goals

#### Short-Term Goal

- Pain relief
- Improve muscle performance
- Improve muscle strength
- Improve balance
- Improve in gait pattern
- Patient education

#### Long-Term Goal

- Return to walking without any difficulty
- Full strength
- Full performance
- Reach full balance

### Plan of Care

#### Interventions/Treatment

The patient received 10 physical therapy sessions in a clinic setting for a 5-week period, from March 27 to April 25, 2024, with two sessions per week, each lasting 45–60 minutes. The intervention was given by a licensed physical therapist. The rehabilitation program included:

- Low-resistance strengthening exercises targeting both upper and lower limbs
- Core stabilization exercises
- Functional mobility training (e.g., sit-stand, walking, bed mobility)
- Pain management strategies including education and rest breaks (exercise intensity and duration were modified based on pain level, fatigue, and tolerance).

Every 3 months, progress was evaluated using standardized functional assessments and clinical reassessment (Table 6).

#### Load Progression Strategy

Strengthening exercises begin at ~50% of the estimated Maximal Voluntary Isometric Contraction (MVIC). Load increased by 5–10% every 4–6 weeks based on patient tolerance, absence of pain (less than 3/10), and functional stability. Volume progressed from 4–6 to 8–12 repetitions per set. High resistance and eccentric exercises were avoided to reduce the risk of muscle damage, following safety protocols reported in DMD literature.<sup>5</sup>

Table 6 | Intervention

Date of Session	Number of Session (S1–S2–S3....)	Plan of Treatment (Enumerate Different Techniques in Details Each Exercise)
27/3/2024	S1	<ul style="list-style-type: none"> <li>• Warm up: gentle active assisted range of motion for hips and knees, seated dynamic movements (5–10 minutes)</li> <li>• Isometric contractions for quadriceps, abductors, hamstrings, internal and external rotations in supine/seated position (30 repetitions/3 seconds hold)</li> <li>• Superman and bird dog exercise (30 repetitions/3 seconds hold)</li> <li>• Bridge exercise (20 repetitions/3 seconds hold)</li> <li>• Ultrasound (7 minutes) at the site of the biopsy in the right femur</li> <li>• Treadmill walking with 0.5 kg ankle weights (speed: 1.5, for 10 minutes)</li> <li>• Climbing up and down stairs using a cane and a 0.5 kg ankle weight</li> <li>• Electrotherapy (10 minutes)</li> <li>• Single-leg stand with support on the right side (30 repetitions/3 seconds hold)</li> <li>• Step up exercise (each leg 10 repetitions/3 seconds hold)</li> <li>• Transfer exercise from a seated to standing position</li> </ul> <p>Initiated at 50% of estimated MVIC (submaximal), progressed to 55–60% over 3 months depending on tolerance</p>
29/3/2024	S2	<ul style="list-style-type: none"> <li>• Isometric contractions for quadriceps, abductors, hamstrings, internal and external rotations in supine/seated position (30 repetitions/3 seconds hold)</li> <li>• Superman and bird dog exercise (30 repetitions/3 seconds hold)</li> <li>• Bridge exercise (20 repetitions/3 seconds hold)</li> <li>• Ultrasound (7 minutes) at the site of the biopsy in the right femur</li> <li>• Treadmill walking with 0.5 kg ankle weights (speed: 1.5, for 10 minutes)</li> <li>• Climbing up and down stairs using a cane and a 0.5 kg ankle weight</li> <li>• Electrotherapy (10 minutes)</li> <li>• Single-leg stand with support on the right side (30 repetitions/3 seconds hold)</li> <li>• Step up exercise (each leg 10 repetitions/3 seconds hold)</li> <li>• Transfer exercise from a seated to standing position</li> </ul>
3/4/2024	S3	<ul style="list-style-type: none"> <li>• Isometric contractions for quadriceps, abductors, hamstrings, internal and external rotations in supine/seated position (30 repetitions/3 seconds hold)</li> <li>• Superman and bird dog exercise (30 repetitions/3 seconds hold)</li> <li>• Bridge exercise (20 repetitions/3 seconds hold)</li> <li>• Ultrasound (7 minutes) at the site of the biopsy in the right femur</li> <li>• Treadmill walking with 1 kg ankle weights (speed: 1.5, for 10 minutes)</li> <li>• Climbing up and down stairs using a cane and a 0.5 kg ankle weight.</li> <li>• Electrotherapy (10 minutes)</li> <li>• Single-leg stand with support on the right side (30 repetitions/3 seconds hold)</li> <li>• Step up exercise (each leg 10 repetitions/3 seconds hold)</li> <li>• Transfer exercise from a seated to standing position.</li> </ul>
6/4/2024	S4	<ul style="list-style-type: none"> <li>• Isometric contractions for quadriceps, abductors, hamstrings, internal and external rotations in supine/seated position (30 repetitions/3 seconds hold)</li> <li>• Superman and bird dog exercise (30 repetitions/3 seconds hold)</li> <li>• Bridge exercise (20 repetitions/3 seconds hold)</li> <li>• Ultrasound (7 minutes) at the site of the biopsy in the right femur</li> <li>• Treadmill walking with 1 kg ankle weights (speed: 1.5, for 10 minutes)</li> <li>• Climbing up and down stairs using a cane and a 0.5 kg ankle weight</li> <li>• Electrotherapy (10 minutes)</li> <li>• Single-leg stand with support on the right side (30 repetitions/3 seconds hold)</li> <li>• Step up exercise (each leg 10 repetitions/3 seconds hold)</li> <li>• Transfer exercise from a seated to standing position</li> </ul>
10/4/2024	S5, S6, S7, S8, S9, S10	<ul style="list-style-type: none"> <li>• Isometric contractions for quadriceps, abductors, hamstrings, internal and external rotations in supine/seated position (30 repetitions/3 seconds hold)</li> <li>• Superman and bird dog exercise (30 repetitions/3 seconds hold)</li> </ul>
13/4/2024 15/4/2024 18/4/2024		<ul style="list-style-type: none"> <li>• Bridge exercise (20 repetitions/3 seconds hold)</li> <li>• Ultrasound (7 minutes) at the site of the biopsy in the right femur</li> <li>• Treadmill walking with 1 kg ankle weights (speed: 1.5, for 10 minutes)</li> <li>• Climbing up and down stairs using a cane and a 0.5 kg ankle weight</li> <li>• Electrotherapy (10 minutes)</li> <li>• Single-leg stand with support on the right side (30 repetitions/3 seconds hold)</li> <li>• Step up exercise (each leg 10 repetitions/3 seconds hold)</li> <li>• Transfer exercise from a seated to standing position</li> </ul>

### Safety Monitoring

Throughout the rehabilitation program, the patient was monitored for signs of exercise-induced muscle damage or adverse events. Monitoring included:

- Clinical observation: using the Wong-Baker FACES Pain Rating Scale, each session included pain monitoring. Exercises were adjusted if pain exceeded 3/10.

- Red flags (functional): decreased performance in ADL, increased fatigue, worsening of gait, were considered warning signs and led to session modifications or rest.
- Parental feedback: the patient's parents reported any delayed soreness, change in functional capacity between sessions, or night pain.
- Biomechanical monitoring (if applicable): serum

**Table 7 | Functional and clinical outcomes pre- and postintervention**

Outcome Measure	Baseline Score	Postintervention Score	Change Score	Clinically Important Difference (CID)
FACES Pain Scale	8/10	4/10	↓ 4 points	CID ≈ 2 points
Tinetti Balance and Gait Assessment	9/28	14/28	↑ 5 points	CID ≈ 3 points
LEFI	61/80	68/80	↑ 7 points	CID ≈ 9 points
Barthel Index (ADL independence)	65/100	75/100	↑ 10 points	CID ≈ 10 points
MMT (hip flexors)	3-/5	4+/5	↑ ~1 grade	Qualitative
MMT (knee extensors)	3/5	3+/5	↑ ~0.5 grade	Qualitative

creatine kinase levels are commonly used in DMD to detect muscle damage; they were not monitored in this case due to resource limitations.

No adverse events or red flags of exercise-induced injury were reported during the treatment sessions.

#### Patient-Related Instructions

- Stay active around the house, avoid prolonged bed rest.
- Do the exercises at your home (superman, bridge, one-leg stand, step up, climb stairs down and up).
- ROM exercises that keep joints flexible and low-impact aerobic exercises such as walking and swimming.
- The mother should stay beside the patient while doing the exercises to reduce the risk of a fall.

#### Reevaluation

The patient has shown significant improvement in many areas. On reevaluation, pain according to the Wong-Baker FACES Pain Rating Scale decreased from 8/10 to 4/10, especially during walking and rolling. Manual muscle testing (MMT) showed mild strength gains, particularly in the hip flexors (right and left: 3 → 4+/5) and knee extensors (right and left: 3 → 3+/5). Gait improved with less waddling and increased endurance for short walks. He regained partial independence in daily activities, such as sitting unsupported, although he still requires assistance in other tasks. Balance and core stability improvements were observed (Table 7).

#### Discussion

This study emphasizes the effect of individualized low-resistance strength training as part of a physical therapy intervention in managing a pediatric patient with DMD, addressing functional limitations related to lower extremity weakness and gait disturbance. Our rehabilitation program included isometric strengthening exercises targeting the hip and knee muscles, core stabilization and strengthening exercises, gait training, and use of therapeutic modalities such as ultrasound and neuromuscular electrotherapy to support muscle activation and pain management. A study done by Donovan J. Lott<sup>5</sup> shows that mild to moderate isometric strengthening, performed at a specified percentage of maximum voluntary muscle contraction over 12 weeks, resulted in improvements in strength and the ability to climb stairs without acute muscle damage.<sup>5</sup> This supports the safety of prescribed resistance training,

contrary to other concerns about exercise-induced exacerbation. Similarly, a clinical controlled study reported that maximal isometric exercise knee extension (4–5 times a week for 6 months) increased maximal muscle torque without leading to muscle damage in pediatric patients with DMD.<sup>7</sup> In addition, a study by Nicoline B.M.<sup>8</sup> combining knee and hip isometrics, gait training, core stabilization, along with the use of neuromuscular electrical stimulation and ultrasound, the clinical results in reduced pain, improved muscle strength, increased independence in activities of daily living, and a better gait pattern.<sup>8</sup> Although direct reports of Tinetti balance score in pediatric DMD are unavailable, related studies confirm significant deficits in mobility and dynamic balance using Timed Up and GO (TUG) test measures, where DMD groups differed from healthy patients  $p < 0.0083$ .<sup>9</sup> These findings support the Tinetti improvements observed in our patient. The LEFS, validated for adolescents (aged 8–18) for lower limb conditions, shows excellent psychometric properties ( $\alpha = 0.972$ ;  $r = 0.859$  correlation with PedsQL physical functioning).<sup>10</sup> The LEFS improvement observed in our patient reflects meaningful functional gains. Application of the Barthel Index to the muscular dystrophy population, including a DMD, has demonstrated acceptable sensitivity to changes in daily living activities, showing certain floor/ceiling limitations.<sup>11</sup> The 10-point increase in our patient suggests a meaningful improvement in independence. This study presents the outcome from a single patient, which limits the generalizability of the findings. Furthermore, due to resource limitations, biomechanical monitoring of creatine kinase levels to assess muscle damage was not feasible. Nevertheless, these results align with both preclinical and clinical studies that reflect the importance of individualization and combining exercise with therapeutic modalities to perfect safety and efficacy. In this case study, the pediatric patient experienced reductions in hip- and gait-related pain, improvements in lower extremity muscle strength, enhanced gait pattern, functional abilities, and increased independence in ADLs, all of which align with the evidence presented in these studies.

#### Patient Perspective

The patient's mother expressed optimism after observing improvements in her child's function, balance, and ability to move around the house more independently. She stated that the structured exercise sessions provided a sense of routine and engagement for her son. She expressed satisfaction with the overall progress.

### Conclusion

This case study supports the clinical value of individualized low-resistance strength training programs as a safe and beneficial intervention provided by physical therapists for pediatric patients with DMD. Through focusing on the patient's functional impairments, including lower limb weakness, gait abnormalities, and reduced independence, the program led to notable improvements in mobility, muscle strength, and daily functioning. The combination of core stabilization, gait training, isometric strengthening, and adjunct modalities such as neuromuscular stimulation and ultrasound shows a positive outcome without causing muscle damage. These findings show the critical role of physical therapy rehabilitation in managing DMD. However, further research involving broader populations is warranted to develop standardized exercise protocols and to assess the long-term safety and effectiveness of such interventions.

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