Muscle Matters: Pathophysiology, Diagnosis and Treatment of Duchenne Muscular Dystrophy

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Accreditation

- Duquesne University School of Pharmacy is accredited by the Accreditation Council for Pharmacy Education as a provider of continuing pharmacy education.
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  - Successfully pass the activity learning assessment within two attempts with a score of 70% or higher
  - Complete an overall activity evaluation

Disclosure

Karina Pelejo, PharmD and Jessica Kuivinen, PharmD do not have any relevant financial relationships with ineligible companies to disclose in relation to this activity.

Objectives

1. Describe the journey of a patient diagnosed with Duchenne Muscular Dystrophy (DMD)
2. Review the pathophysiology, diagnostic criteria and clinical manifestations of DMD
3. Discuss current management strategies and therapies in the pipeline for patients with DMD

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Nicolas' Journey

Click here to view Nicolas' Story:

https://www.nytimes.com/video/health/100000005099028/duchenne-muscular-dystrophy-exondys.html

Objectives

1. Describe the journey of a patient diagnosed with Duchenne muscular dystrophy
2. **Review the pathophysiology, diagnostic criteria and clinical manifestations of DMD**
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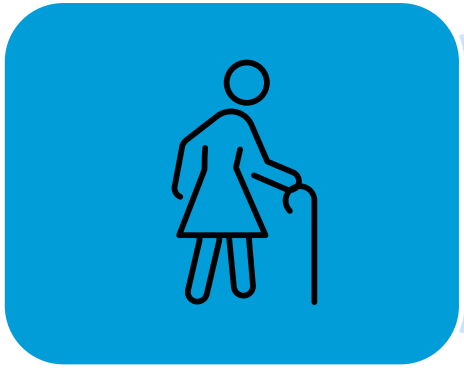
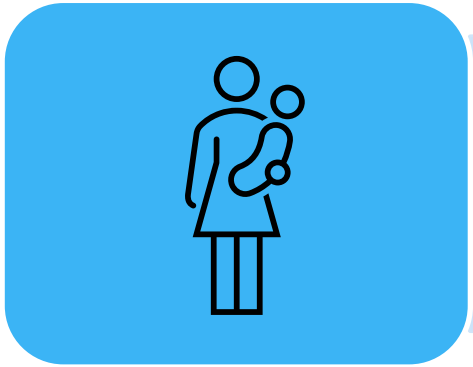
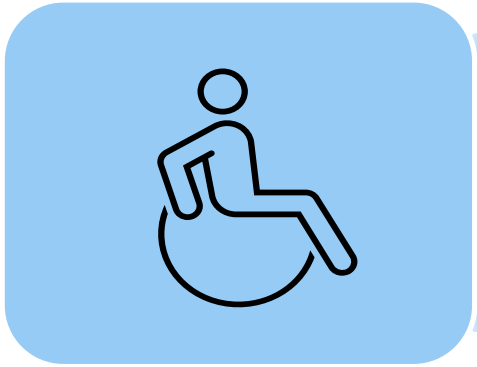
What is Duchenne Muscular Dystrophy?



An inherited, severe and progressive muscle-wasting disease



Patients exhibit symptoms around 2 years of age and are diagnosed at ≥ 4 years

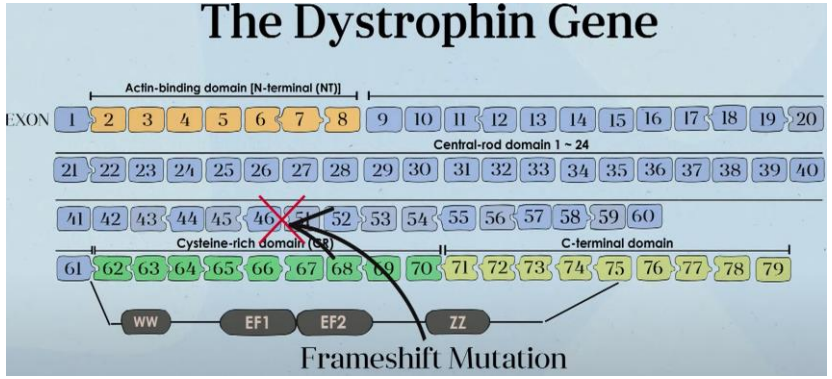


Mobility limitations develop over time, and many patients become wheelchair dependent

Duan D, Goemans N, Takeda S, Mercuri E, Aartsma-Rus A. Duchenne muscular dystrophy. *Nat Rev Dis Primers*. 2021;7(1):13. Published 2021 Feb 18. doi:10.1038/s41572-021-00248-3
Bez Batti Angulski A, Hosny N, Cohen H, et al. Duchenne muscular dystrophy: disease mechanism and therapeutic strategies. *Front Physiol*. 2023;14:1183101. Published 2023 Jun 26. doi:10.3389/fphys.2023.1183101

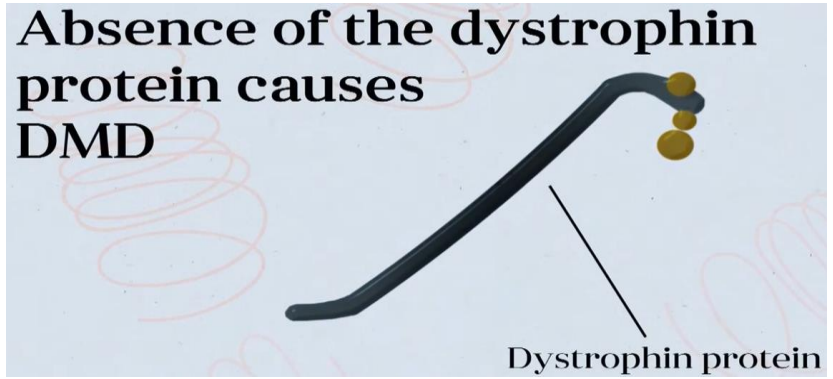
Pathophysiology

1



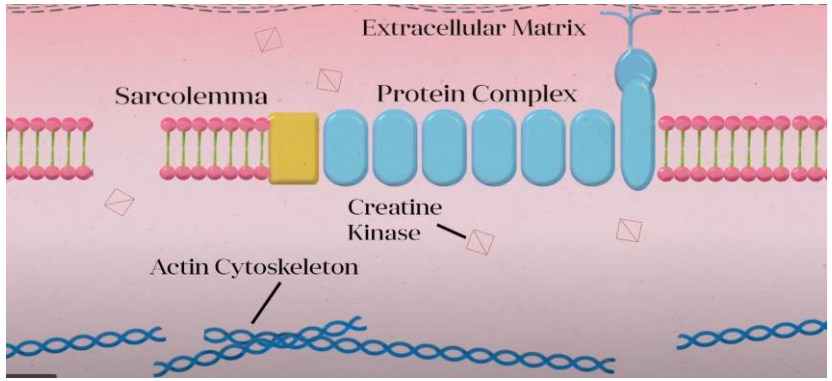
For dystrophin to be produced, 79 exons are required

2



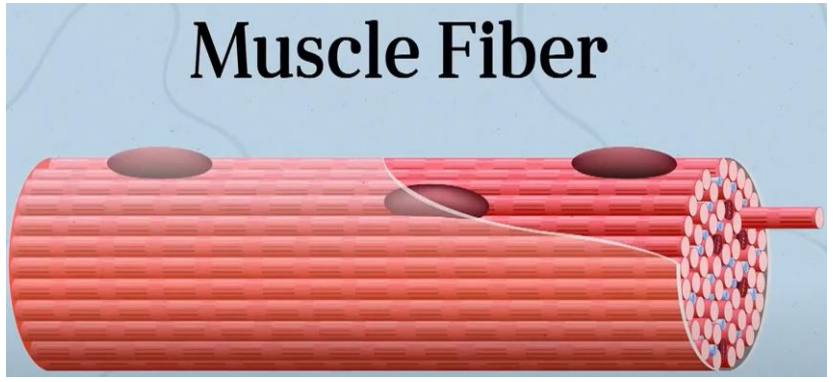
Exon deletions in the dystrophin gene cause a lack of functional dystrophin protein

3



In the absence of dystrophin, repeated muscle contractions damage muscle fibers

4



Over time, muscle fibers are replaced with fat and scar tissue, and everyday muscle use will result in necrosis and degradation

The France Foundation. Genes, Exons, and the Pathophysiology of DMD (Duchenne Muscular Dystrophy). [YouTube]. June 24, 2021.

The Role of Genetics in DMD

DMD is caused by dystrophin gene variants

- The reading frame indicates the **severity** of the disease
  - ❖ Out-of-frame variants cause DMD
  - ❖ In-frame variants cause BMD

DMD is an X-linked recessive disease

- **Males** are more prevalently affected
- Female carriers often exhibit **no symptoms**, but they may pass the mutation onto their offspring

BMD = Becker muscular dystrophy

Bez Batti Angulski A, Hosny N, Cohen H, et al. Duchenne muscular dystrophy: disease mechanism and therapeutic strategies. *Front Physiol*. 2023;14:1183101. Published 2023 Jun 26. doi:10.3389/fphys.2023.1183101

Epidemiology

United States

2 per 10,000 people are affected

15,000 patients nationwide

Worldwide

1 in 3,600 people are affected

300,000 patients globally

Venugopal V, Pavlakis S. Duchenne Muscular Dystrophy. [Updated 2023 Jul 10]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan.

Clinical Presentation

Onset and Progression

- Symptoms typically begin at **age 2**
- **Muscle weakness** is the hallmark symptom
- Average life expectancy is **28.1 years**

Muscle Involvement

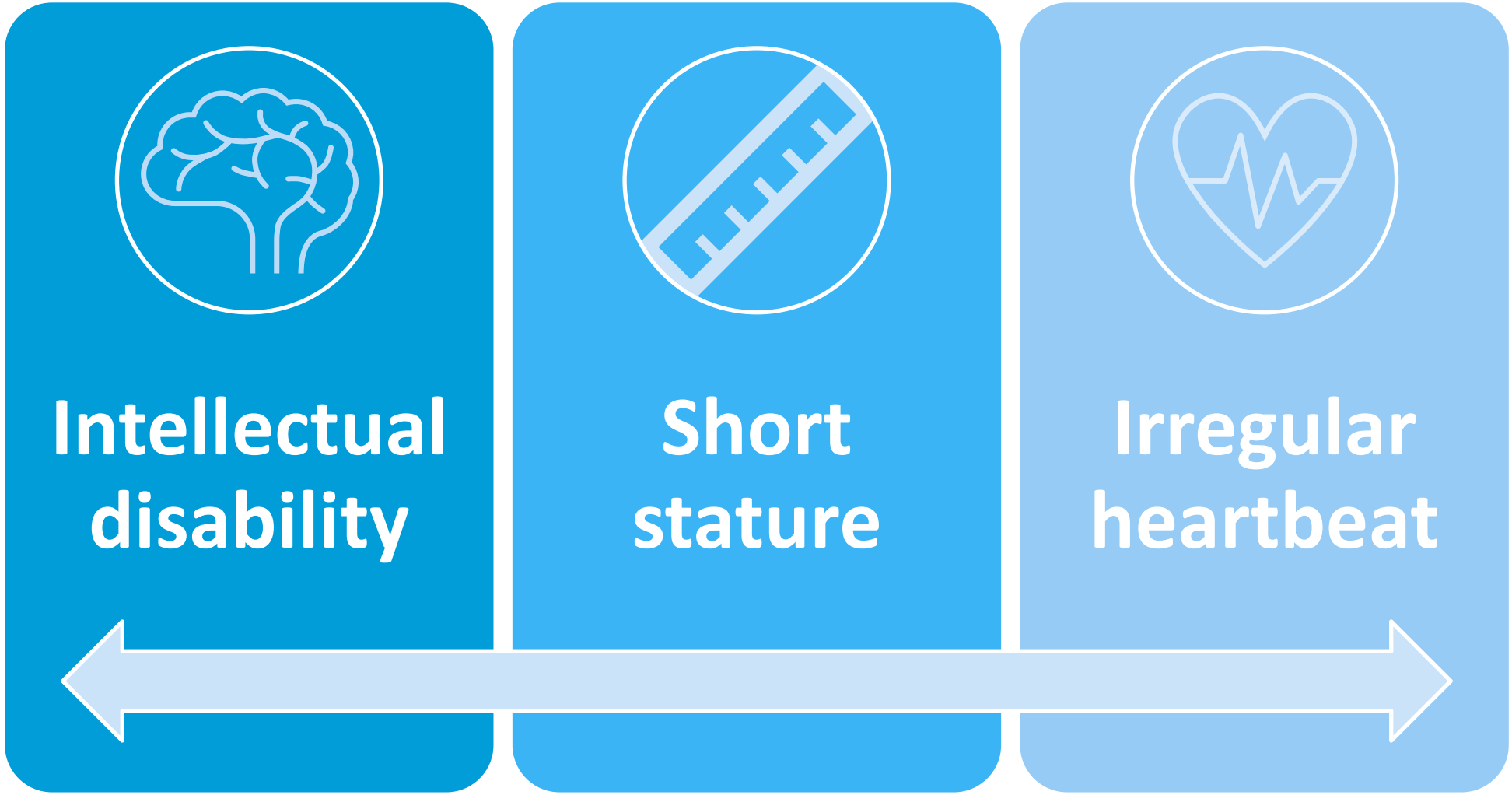
- **Proximal muscles** are affected first
  - ❖ Hips
  - ❖ Thighs
- Then, **distal muscles** are affected
  - ❖ Hands
  - ❖ Feet

Other Common Signs

- **Delayed motor milestones**
- Waddling gait
- Scoliosis
- **Frequent falls and contractures**
- Calf pseudohypertrophy
- Fatigue

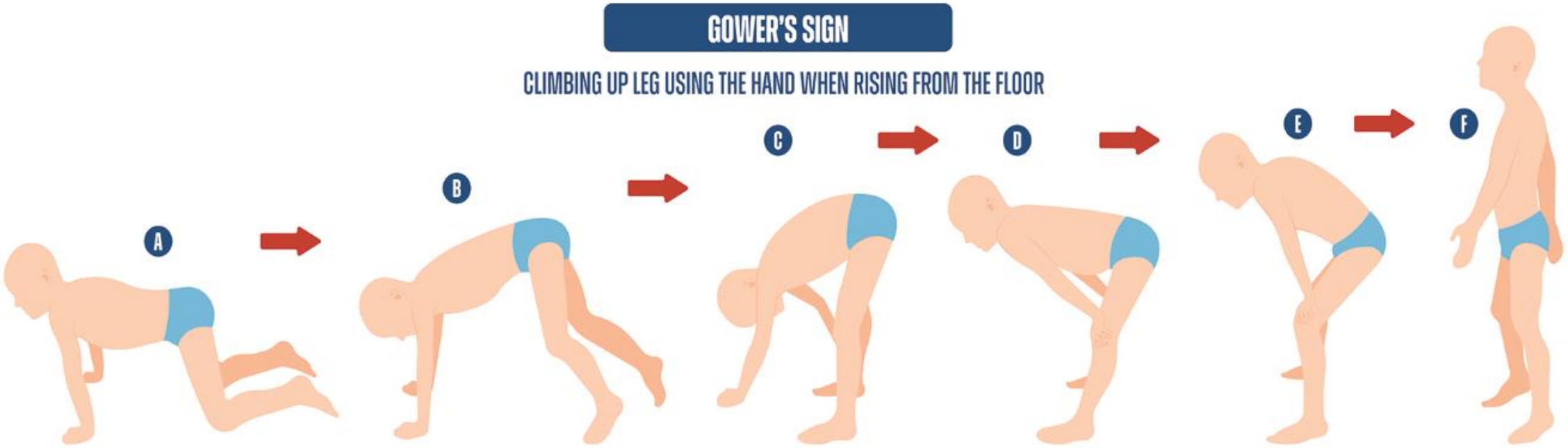
Broomfield J, Hill M, Guglieri M, Crowther M, Abrams K. Life Expectancy in Duchenne Muscular Dystrophy: Reproduced Individual Patient Data Meta-analysis. *Neurology*. 2021;97(23):e2304-e2314. doi:10.1212/WNL.0000000000012910
Duan D, Goemans N, Takeda S, Mercuri E, Aartsma-Rus A. Duchenne muscular dystrophy. *Nat Rev Dis Primers*. 2021;7(1):13. Published 2021 Feb 18. doi:10.1038/s41572-021-00248-3

Additional Signs



Venugopal V, Pavlakis S. Duchenne Muscular Dystrophy. [Updated 2023 Jul 10]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan.
Shrestha S, Munakomi S. Gower Sign. [Updated 2023 Feb 13]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan.

Gower’s Sign



Defeat Duchenne Canada. *Signs and Symptoms*. Accessed December 10, 2025.

Disease Progression

6 years old and younger

- Muscle weakness is a principal symptom seen early on
- Toe walking, difficulty running and climbing stairs
- Milestones are achieved at a delayed rate
- Poor head control and mild hypotonia

6 to 13 years

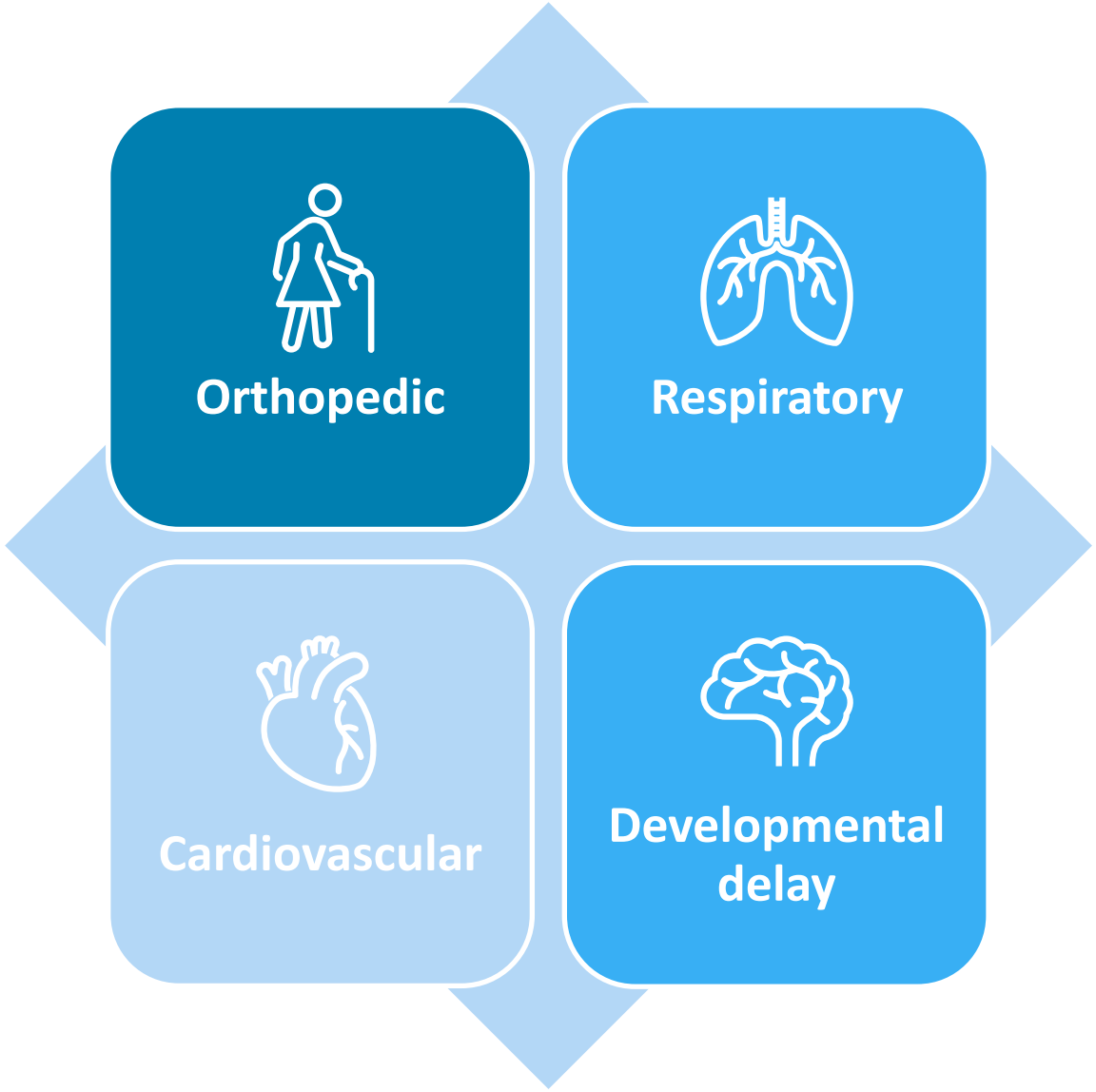
- Ambulation becomes more difficult as the patient ages
- Likely to become more wheelchair-dependent
- Simple tasks may become more complicated

13 years and older

- Further loss of ambulation
- Orthopedic, respiratory and cardiac complications
- Wheelchair-dependent
- A caregiver may be needed

Venugopal V, Pavlakis S. Duchenne Muscular Dystrophy. [Updated 2023 Jul 10]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan.

Complications of DMD



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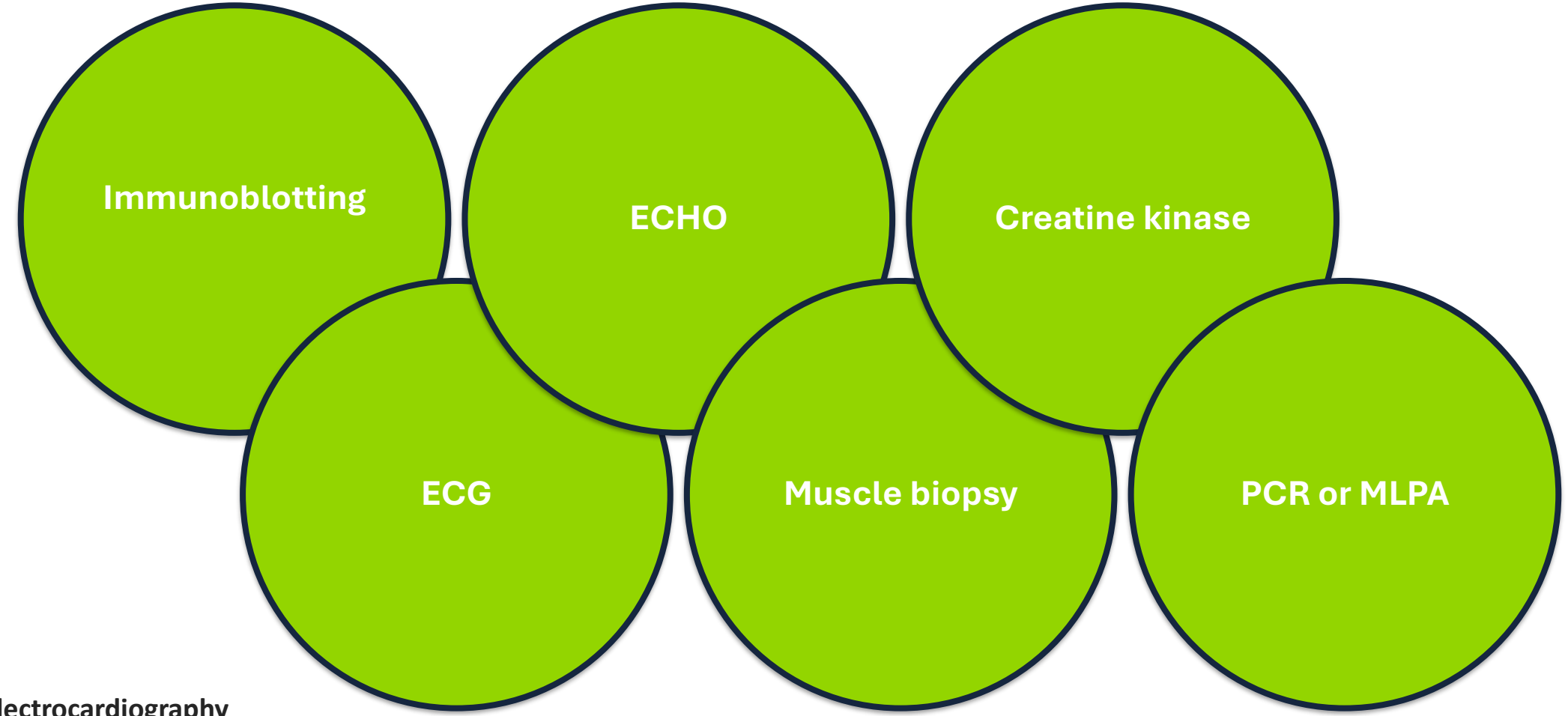
Diagnostic Workup



ECG = electrocardiography
ECHO = echocardiogram
PCR = polymerase chain reactions
MLPA = multiplex ligation probe amplification

Duan D, Goemans N, Takeda S, Mercuri E, Aartsma-Rus A. Duchenne muscular dystrophy. *Nat Rev Dis Primers*. 2021;7(1):13. Published 2021 Feb 18. doi:10.1038/s41572-021-00248-3

Genetic Testing

Genetic Testing Significance

- Predicts the **phenotype, disease severity** and helps **guide** treatment
- Assesses mutation size and location

Unknown Family Variant

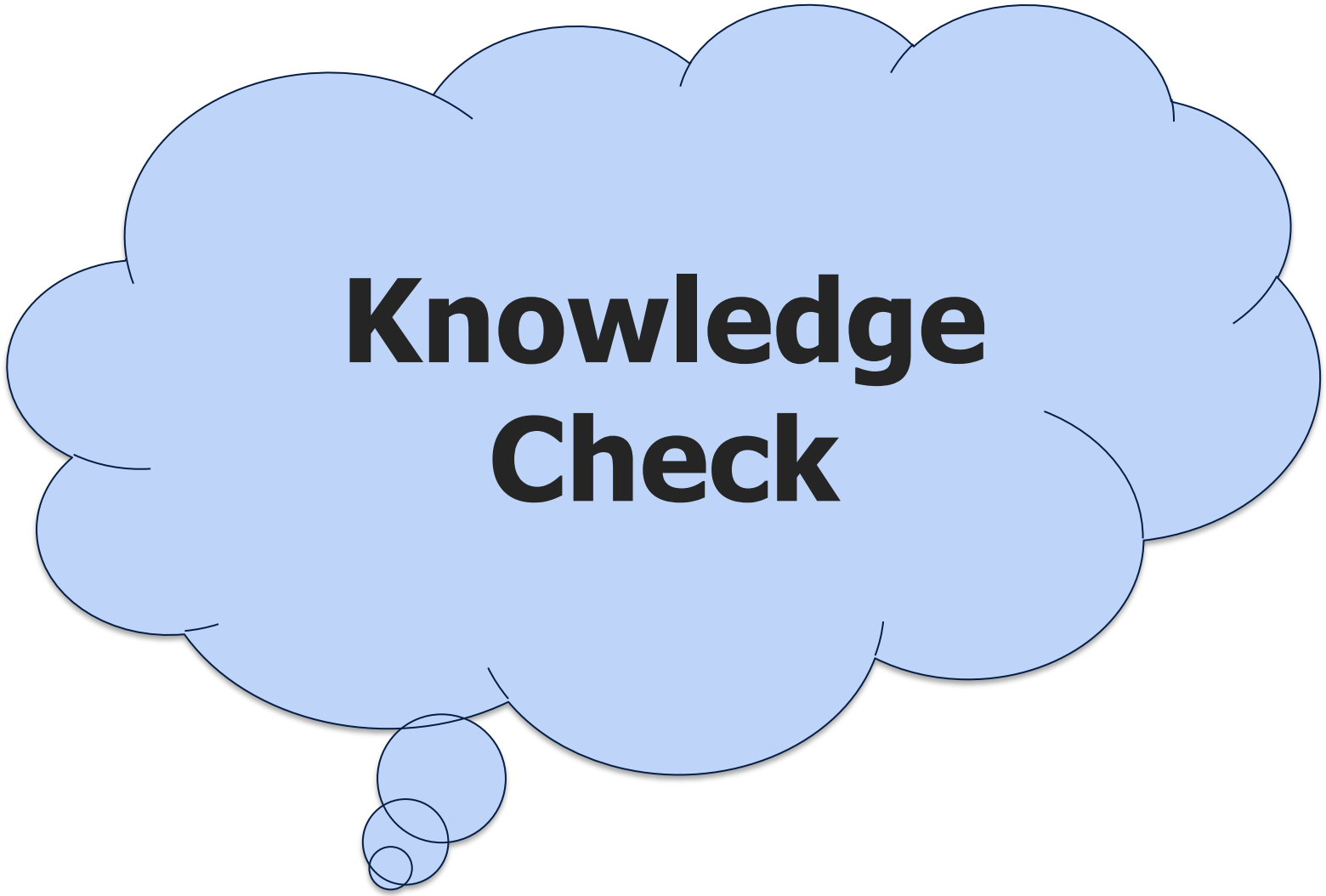
- If the **variant** in your family in **not known**:
  - ❖ MLPA or CGH testing may be completed to identify duplications and deletions

Known Family Variant

- If the **variant** in your family is **known**:
  - ❖ Familial variant testing should be completed
  - ❖ This test looks for specific variants that have been identified in the patient's family

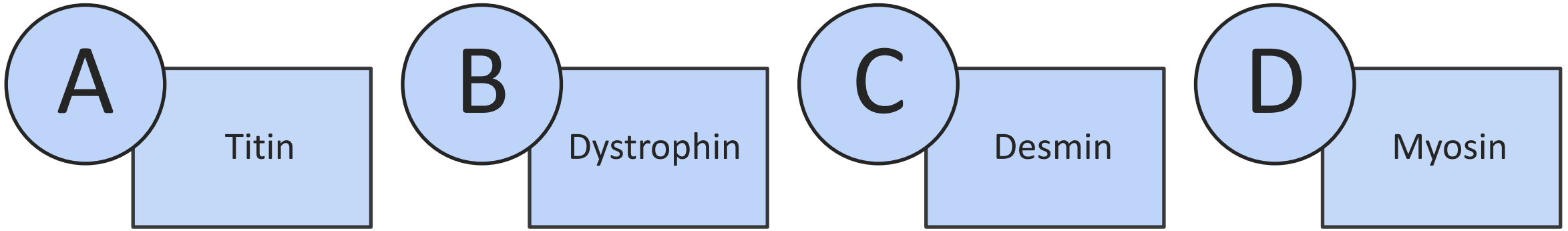
CGH = comparative genomic hybridization
MLPA = multiplex ligation dependent probe amplification

Parent Project Muscular Dystrophy. Genetic testing for Duchenne.



Knowledge Check

Progressive muscle weakness and muscle fiber degeneration in DMD are commonly associated with mutations in which gene?



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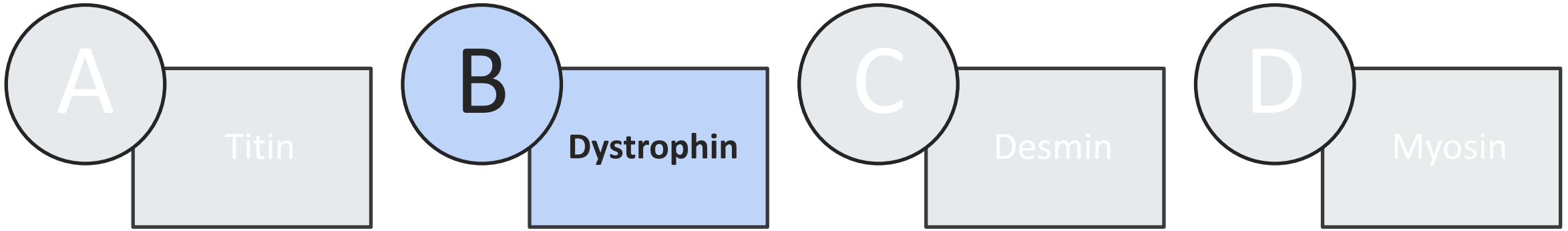
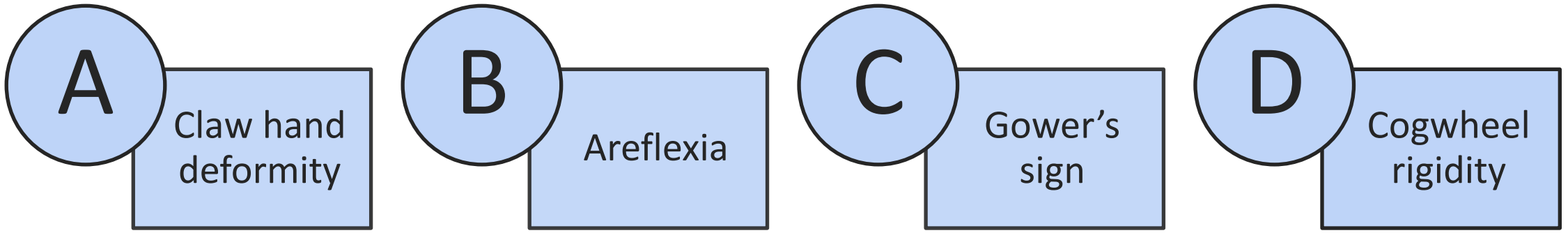


Knowledge Check

Which clinical sign is commonly observed in children with DMD?



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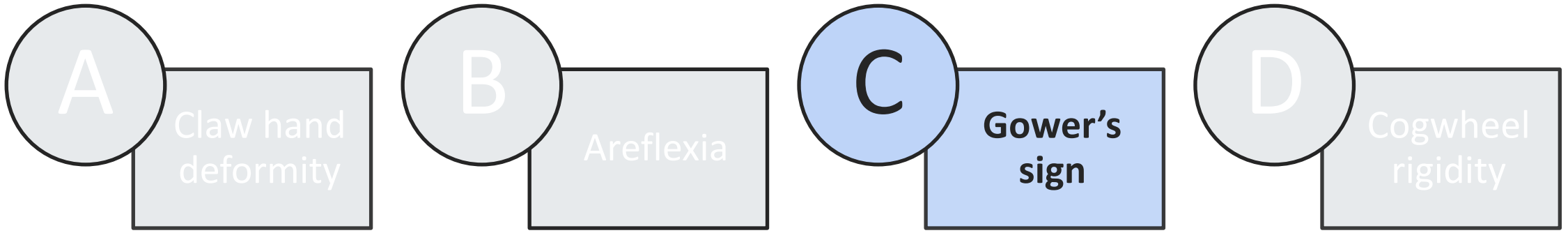

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2. Review the pathophysiology, diagnostic criteria and clinical manifestations of DMD
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General Management

Mah JK. Therapeutic options for Duchenne muscular dystrophy: hope or hype?. *Ther Adv Neurol Disord*. 2025;18:17562864251346326. Published 2025 Jun 21. doi:10.1177/17562864251346326
Parent Project Muscular Dystrophy. Imperatives for Duchenne Muscular Dystrophy. Published April 2018.
TREAT-NMD. Duchenne Muscular Dystrophy Care Guide.

Prednisone

Indication

- Often used off-label for DMD

Mechanism

- Inhibit the inflammatory cascades that cause acute tissue damage

Dose + Route of Administration

- 0.75 mg/kg/day
- Dosage Form(s): tablet, oral solution

Adverse Effects

- Fluid retention and weight gain
- Elevated blood pressure and blood glucose
- Behavioral and mood changes

US Food and Drug Administration. Prednisone [package insert]. Silver Spring, MD: US Food and Drug Administration; March 2024.
Matthews E, Brassington R, Kuntzer T, Jichi F, Manzur AY. Corticosteroids for the treatment of Duchenne muscular dystrophy. *Cochrane Database Syst Rev*. 2016;2016(5):CD003725. Published 2016 May 5. doi:10.1002/14651858.CD003725.pub4

Meta-Analysis of Corticosteroids

Trial Selection

- 12 RCTs of patients who have been treated with corticosteroids (prednisone, prednisolone and deflazacort) for a minimum of three months were included in this meta-analysis
  - ❖ n = 667

Primary Outcomes

- Data were not adequate for drawing conclusions on the prolongation of ambulation

Secondary Outcomes

- 0.75 mg/kg/day prednisone or prednisolone improved muscle strength and function compared to placebo
- 0.75 mg/kg/day prednisone or prednisolone was superior to 0.3 mg/kg/day on most strength and function measures

RCT = randomized controlled trial

Quattrocelli M, Zelikovich AS, Salamone IM, Fischer JA, McNally EM. Mechanisms and clinical applications of glucocorticoid steroids in muscular dystrophy. *J Neuromuscul Dis.* 2021;8(1):1-15. doi:10.3233/JND-200556.

Deflazacort

Indication

- FDA approved for DMD in patients 5 years and older

Mechanism

- Prodrug that acts through the glucocorticoid receptor to exert anti-inflammatory and immunosuppressive effects
- Exact mechanism by which deflazacort exerts therapeutic effects in DMD is unknown

Dose + Route of Administration

- 0.9 mg/kg/day
- Dosage form(s): tablet, oral suspension

Adverse Effects

- Weight gain
- Upper respiratory tract infections
- Nasopharyngitis
- Pollakiuria

US Food and Drug Administration. Emflaza (deflazacort) [package insert]. Silver Spring, MD: US Food and Drug Administration; February 2017.

Deflazacort vs. Prednisone in DMD

Trial Characteristics

- Phase 3, double-blind, randomized, placebo-controlled, multicenter study
  - ❖ *n* = 196

Study Populations

- Deflazacort 0.9 mg/kg/day (*n* = 51)
- Deflazacort 1.2 mg/kg/day (*n* = 49)
- Prednisone 0.75 mg/kg/day (*n* = 46)
- Placebo (*n* = 50)

Primary Analysis

- Average change in muscle strength from baseline to week 12

Primary Endpoint Results

- All treatment groups demonstrated significant improvement in muscle strength
- Participants taking prednisone had more weight gain than patients in the placebo or deflazacort treated groups

Griggs RC, Miller JP, Greenberg CR, et al. Efficacy and safety of deflazacort vs prednisone and placebo for Duchenne muscular dystrophy. *Neurology*. 2016;87(20):2123-2131. doi:10.1212/WNL.0000000000003217

Vamorolone

Indication

- FDA approved for patients with DMD who are 2 years and older

Mechanism

- Prodrug that acts through the glucocorticoid receptor to exert anti-inflammatory and immunosuppressive effects
- Exact mechanism in DMD is unknown

Dose + Route of Administration

- 6 mg/kg once daily preferably with a meal
- Dosage form(s): oral suspension

Adverse Effects

- Psychiatric disorders
- Vomiting
- Weight gain

US Food and Drug Administration. Vamorolone [package insert]. Silver Spring, MD: US Food and Drug Administration; October 2023.

Vamorolone vs. Prednisone vs. Placebo in DMD

Trial Characteristics

- Phase 2b, randomized, double-blind, placebo-controlled 24-week study
  - ❖ *n* = 121

Study Populations

- Ambulatory, steroid-naïve males aged 4-7 years old
  - ❖ Prednisone 0.75 mg/kg/day (*n* = 31)
  - ❖ Vamorolone 2 mg/kg/day (*n* = 30)
  - ❖ Vamorolone 6 mg/kg/day (*n* =30)
  - ❖ Placebo (*n* = 30)

Primary Analysis

- Time to stand from supine at 24 weeks

Primary Endpoint Results

- Vamorolone 6 mg/kg/day: 0.05 meters per second decrease in time to stand from supine
- Placebo: 0.01 meter per second increase in time to stand from supine

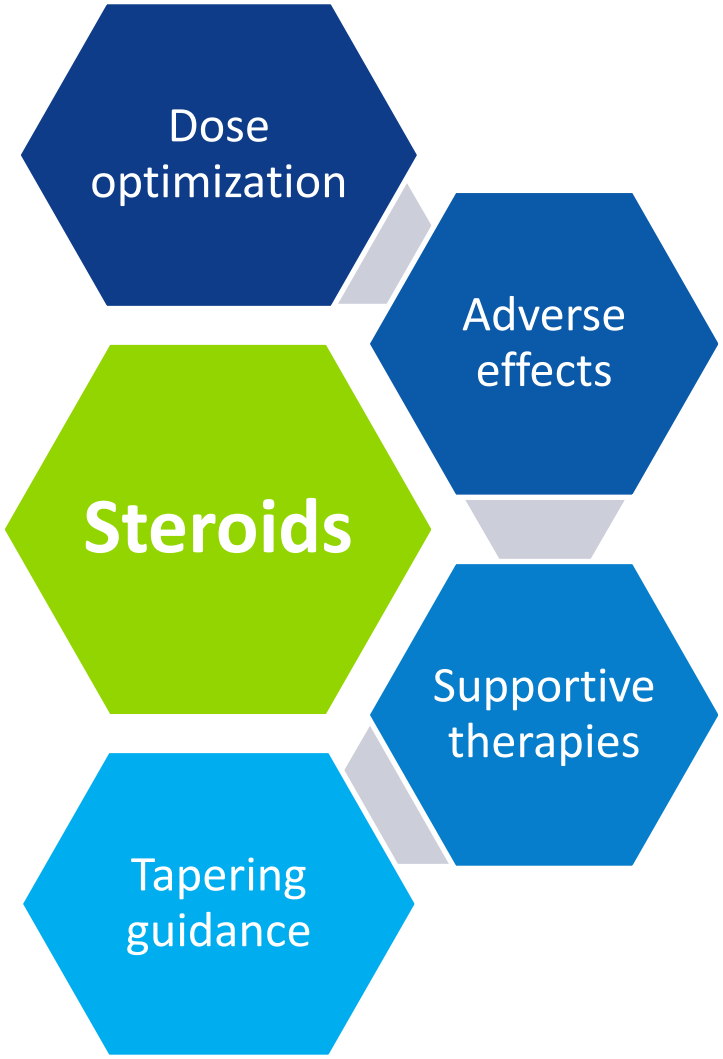
Griggs RC, Miller JP, Greenberg CR, et al. Efficacy and safety of deflazacort vs prednisone and placebo for Duchenne muscular dystrophy. *Neurology*. 2016;87(20):2123-2131. doi:10.1212/WNL.0000000000003217

Corticosteroid Dosing Regimens in DMD

- A systematic review and meta-analysis compared the efficacy and safety of **daily vs. intermittent prednisone**
- A total of **6 trials** were included (RCTs and observational cohorts)
  - *n* = 708
- There were **no statistically significant differences** between daily vs. intermittent prednisone in terms of blood pressure, loss of ambulation, weight changes, bone fracture, and behavioral changes
- **Intermittent prednisone** was associated with a higher prevalence of cushingoid appearance (p= 0.005), excessive hair growth (p= 0.02), and hypertension (p < 0.0001)

Zulfiqar E, Hurjkaliani S, Umar SA, et al. Comparing intermittent and daily prednisone in duchenne muscular dystrophy: a systematic review and meta-analysis. *Ann Med Surg (Lond)*. 2025;87(3):1637-1645. Published 2025 Feb 27. doi:10.1097/MS9.0000000000003049

Role of the Pharmacist: Corticosteroids



- Ensuring that the patient is on an **appropriate drug and dose** based on their weight, side effect profile and response to therapy
- Counsel patients on common **adverse effects** and monitoring parameters such as blood pressure, weight and osteoporosis
- Recommending **supportive therapies** such as calcium and vitamin D supplements or bisphosphonates for long-term steroid use
- Ensure that patients **taper** off their steroid to prevent adrenal insufficiency when discontinuing

Quattrocelli M, Zelikovich AS, Salamone IM, Fischer JA, McNally EM. Mechanisms and clinical applications of glucocorticoid steroids in muscular dystrophy. *J Neuromuscul Dis.* 2021;8(1):1-15. doi:10.3233/JND-200556.
Matthews E, Brassington R, Kuntzer T, Jichi F, Manzur AY. Corticosteroids for the treatment of Duchenne muscular dystrophy. *Cochrane Database Syst Rev*. 2016;2016(5):CD003725. Published 2016 May 5. doi:10.1002/14651858.CD003725.pub4

Exon Skipping Therapy

Indication

- FDA approved for the treatment of DMD in patients who have a confirmed DMD gene mutation

Mechanism

- Exon skipping therapies bind to a specific exon, resulting in the exclusion of this exon during mRNA processing
- This allows for dystrophin production in patients with mutations that are amenable to that specific exon

Dose + Route of Administration

- Casimersen, Golodiresen and Eteplirsen – 30 mg/kg IV infusion once weekly
- Viltolarsen – 80 mg/kg IV infusion once weekly

Adverse Effects

- Casimersen – upper respiratory tract infections, cough, pyrexia, headache
- Golodirsen – nasopharyngitis, nausea, vomiting, pyrexia
- Eteplirsen – balance disorder, vomiting
- Viltolarsen – injection site reaction, upper respiratory tract infection, pyrexia

US Food and Drug Administration. Viltepso (viltolarsen) [package insert]. Silver Spring, MD: US Food and Drug Administration; August 2021.
US Food and Drug Administration. Vyondys 53 (golodirsen) [package insert]. Silver Spring, MD: US Food and Drug Administration; December 2019.
US Food and Drug Administration. Exondys 51 (eteplirsen) [package insert]. Silver Spring, MD: US Food and Drug Administration; September 2016.
US Food and Drug Administration. Amondys 45 (casimersen) [package insert]. Silver Spring, MD: US Food and Drug Administration; February 2021.

Rationale for Exon Skipping

The **X-linked mutation** in the dystrophin gene disrupts the reading frame and **stops** dystrophin production

Exon-skipping drugs **“mask”** specific exons during mRNA processing

Skipping restores the reading frame, enabling production of a **shorter but functional** dystrophin protein

Therapy is **mutation-specific** (ex. skipping exon 45, 51, 53)

Restoration of some dystrophin leads to **reduction** of muscle fiber damage and **slowing** of inflammation and weakness

Exon skipping directly addresses the **underlying genetic defect**

Echigoya Y, Lim KRQ, Nakamura A, Yokota T. Multiple Exon Skipping in the Duchenne Muscular Dystrophy Hot Spots: Prospects and Challenges. *J Pers Med*. 2018;8(4):41. Published 2018 Dec 7. doi:10.3390/jpm804004

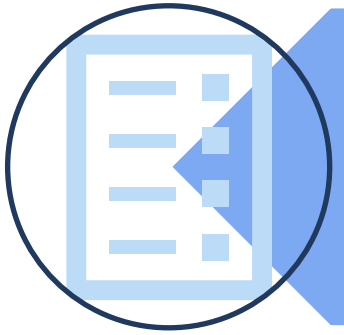
RACER53 Trial

RACER53 trial

- Phase 2, open-label, 192-week long term extension study
  - ❖ *n* = 16

Baseline Characteristics

- DMD patients with gene mutations amenable to exon 53 skipping
- 4-9 years old



Trial Populations

- Group 1: Viltolarsen 40 mg/kg/week (*n* = 6)
- Group 2: Placebo for 4 weeks, then Viltolarsen 40 mg/kg/week (*n* = 2)
- Group 3: Viltolarsen 80 mg/kg/week (*n* = 6)
- Group 4: Placebo for 4 weeks, then Viltolarsen 80 mg/kg/week (*n* = 2)

Clemens PR, Rao VK, Connolly AM, et al. Efficacy and Safety of Viltolarsen in Boys With Duchenne Muscular Dystrophy: Results From the Phase 2, Open-Label, 4-Year Extension Study. *J Neuromuscul Dis.* 2023;10(3):439-447. doi:10.3233/JND-221656

RACER53 Trial

Primary Outcome

- Dystrophin protein production

Primary Outcome Results

- Viltolarsen 40 mg/kg/week: 5.7% mean increase in dystrophin expression
- Viltolarsen 80 mg/kg/week: 5.9% mean increase in dystrophin expression

Clemens PR, Rao VK, Connolly AM, et al. Efficacy and Safety of Viltolarsen in Boys With Duchenne Muscular Dystrophy: Results From the Phase 2, Open-Label, 4-Year Extension Study. *J Neuromuscul Dis*. 2023;10(3):439-447. doi:10.3233/JND-221656
Sarepta Therapeutics, Inc. North Star Ambulatory Assessment (NSAA) fact sheet. Cambridge, MA: Sarepta Therapeutics, Inc.; April 2021.

Role of the Pharmacist: Exon Skipping Therapy

- Review and interpret genetic test results
- Identify mutations amenable to exon skipping
- Guide therapy decisions based on specific mutation

Pharmacogenomics

- Renal toxicity
  - ❖ Decreased urine output
  - ❖ Monitor kidney function
- Infusion-related reactions
  - ❖ Flushing, fever, chills

Side effect counseling

Echigoya Y, Lim KRQ, Nakamura A, Yokota T. Multiple Exon Skipping in the Duchenne Muscular Dystrophy Hot Spots: Prospects and Challenges. *J Pers Med*. 2018;8(4):41. Published 2018 Dec 7. doi:10.3390/jpm804004

Givinostat

Indication

- FDA approved for the treatment of DMD in patients 6 years of age and older

Mechanism

- Histone deacetylase inhibitor

Dose + Route of Administration

- Oral suspension (8.86 mg/mL) administered twice daily with food

Adverse Effects

- Diarrhea, abdominal pain, thrombocytopenia, nausea, and elevated triglycerides

Syed N, Un Nisa Mughal Z, Haseeb A, Alemam Manhal G, Yasir Eissa A, Abbasher Hussien Mohamed Ahmed K. Duvyzat (givinostat): a new hope for Duchenne muscular dystrophy patients. *Ann Med Surg (Lond)*. 2025;87(5):2529-2531. Published 2025 Mar 28. doi:10.1097/MS9.0000000000003196
talfarmaco Therapeutics. Duvyzat (givinostat) [prescribing information]. Boston, MA: Italfarmaco Therapeutics; 2024.
Italfarmaco S.p.A. Dosing and monitoring for Duvyzat. Duvyzat website.

EPIDYS Trial

Phase 3 EPIDYS Trial

- Randomized, double-blind, placebo-controlled
- 18-month trial
- *n* = 179

Baseline Characteristics

- Ambulatory males with DMD who have been on a consistent dose of steroids for at least 6 months
- ≥ 6 years and older

Trial Populations

- Givinostat 10 mg/mL oral suspension
  - ❖ *n* = 118
- Placebo
  - ❖ *n* = 61

Primary Analysis

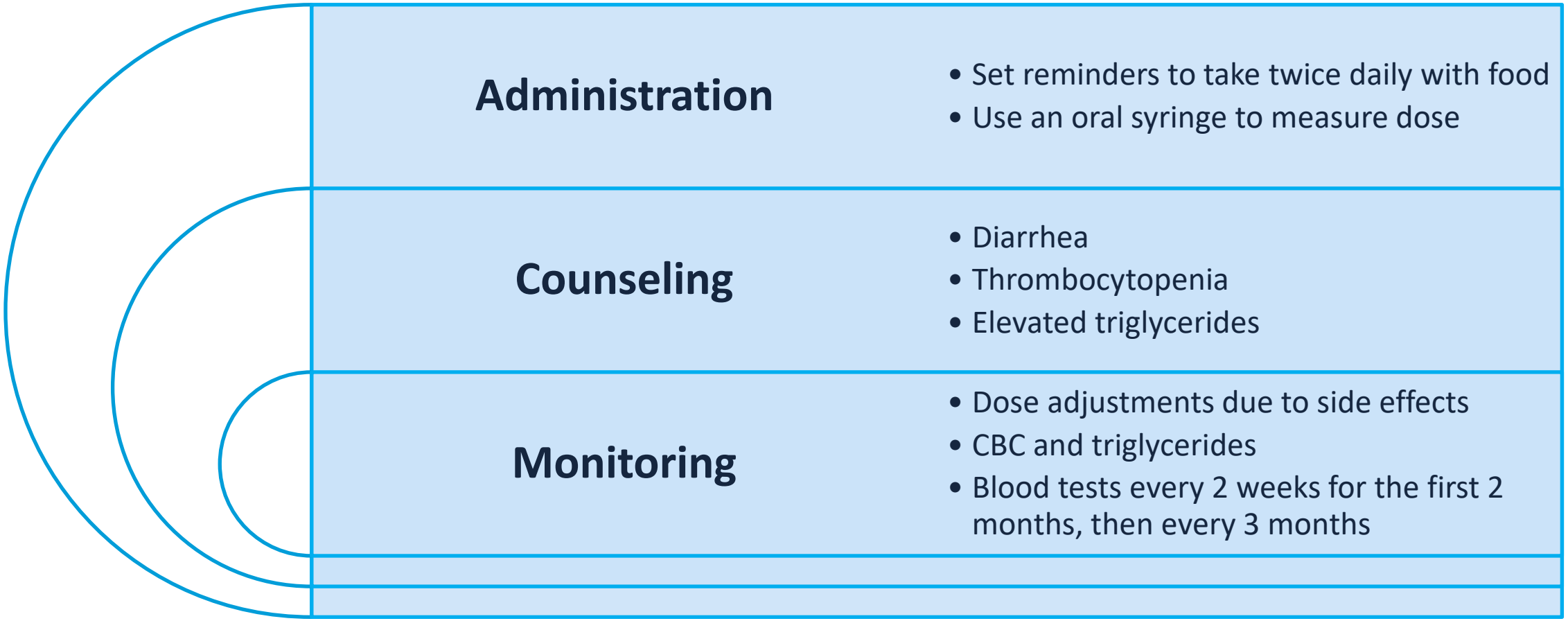
- Mean change in the 4-stair climb (4SC)

Primary Endpoint Result

- Patients treated with givinostat had a statistically significant reduction in 4SC times and fat infiltration

Mercuri E, Vilchez JJ, Boespflug-Tanguy O, et al. Safety and efficacy of givinostat in boys with Duchenne muscular dystrophy (EPIDYS): a multicentre, randomised, double-blind, placebo-controlled, phase 3 trial. *Lancet Neurol*. 2024;23(4):393-403. doi:10.1016/S1474-4422(24)00036-X

Role of the Pharmacist: Givinostat



CBC = complete blood count

Syed N, Un Nisa Mughal Z, Haseeb A, Alemam Manhal G, Yasir Eissa A, Abbasher Hussien Mohamed Ahmed K. Duvyzat (givinostat): a new hope for Duchenne muscular dystrophy patients. *Ann Med Surg (Lond)*. 2025;87(5):2529-2531. Published 2025 Mar 28. doi:10.1097/MS9.0000000000003196

Delandistrogene moxeparvovec

Indication

FDA approved for the treatment of DMD in ambulatory and non-ambulatory patients that are 4 years or older

Mechanism

Adeno-associated virus vector-based gene therapy

Dose + Route of Administration

10-70 kg: 1.33 $x10^{14}$ vector genomes/kg in a single-dose IV infusion

$\geq$ 70 kg: 9.31 x 10^{15} vector genomes/kg in a single-dose IV infusion

Adverse Effects

Nausea, vomiting, liver injury, pyrexia and thrombocytopenia

Sarepta Therapeutics, Inc. Elevidys (delandistrogene moxeparvovec-rokl) [prescribing information]. Cambridge, MA: Sarepta Therapeutics, Inc.; 2023.

EMBARK Trial

Phase 3 EMBARK Trial

- Multi-national, randomized, double-blind, placebo-controlled, 52-week trial
- *n* = 125

Baseline Characteristics + Trial Populations

- Ambulatory males aged 4-7 years with a diagnosis of DMD
- Delandistrogene moxeparvovec: 1.33×10^{14} vector genomes/kg
  - ❖ *n* = 63
- Placebo
  - ❖ *n* = 62

Mendell JR, Muntoni F, McDonald CM, et al. AAV gene therapy for Duchenne muscular dystrophy: the EMBARK phase 3 randomized trial. *Nat Med*. 2025;31(1):332-341. doi:10.1038/s41591-024-03304-z

EMBARK Trial

Trial Endpoints

- **Primary:** Change from baseline in North Star Ambulatory Assessment (NSAA) score
- **Secondary:** Average micro-dystrophin expression at week 12

Endpoint Results

- **Primary: Change in NSAA Scores**
  - ❖ Delandistrogene moxeparvovec: score increase of 2.57 points
  - ❖ Placebo: score increase of 1.92 points
  - ❖ p = 0.2441
- **Secondary: Micro-dystrophin expression at week 12**
  - ❖ Delandistrogene moxeparvovec: 34.29% expression
  - ❖ Placebo: 0% expression

Mendell JR, Muntoni F, McDonald CM, et al. AAV gene therapy for Duchenne muscular dystrophy: the EMBARK phase 3 randomized trial. *Nat Med*. 2025;31(1):332-341. doi:10.1038/s41591-024-03304-z

Role of the Pharmacist: Delandistrogene moxeparvovec

Pre-treatment management

- Corticosteroid regimen
- Reduces immune response

Monitoring

- Infusion-related reactions
- Monitor for 3 hours after infusion

Treatment risks

- Myocarditis
- Liver injury

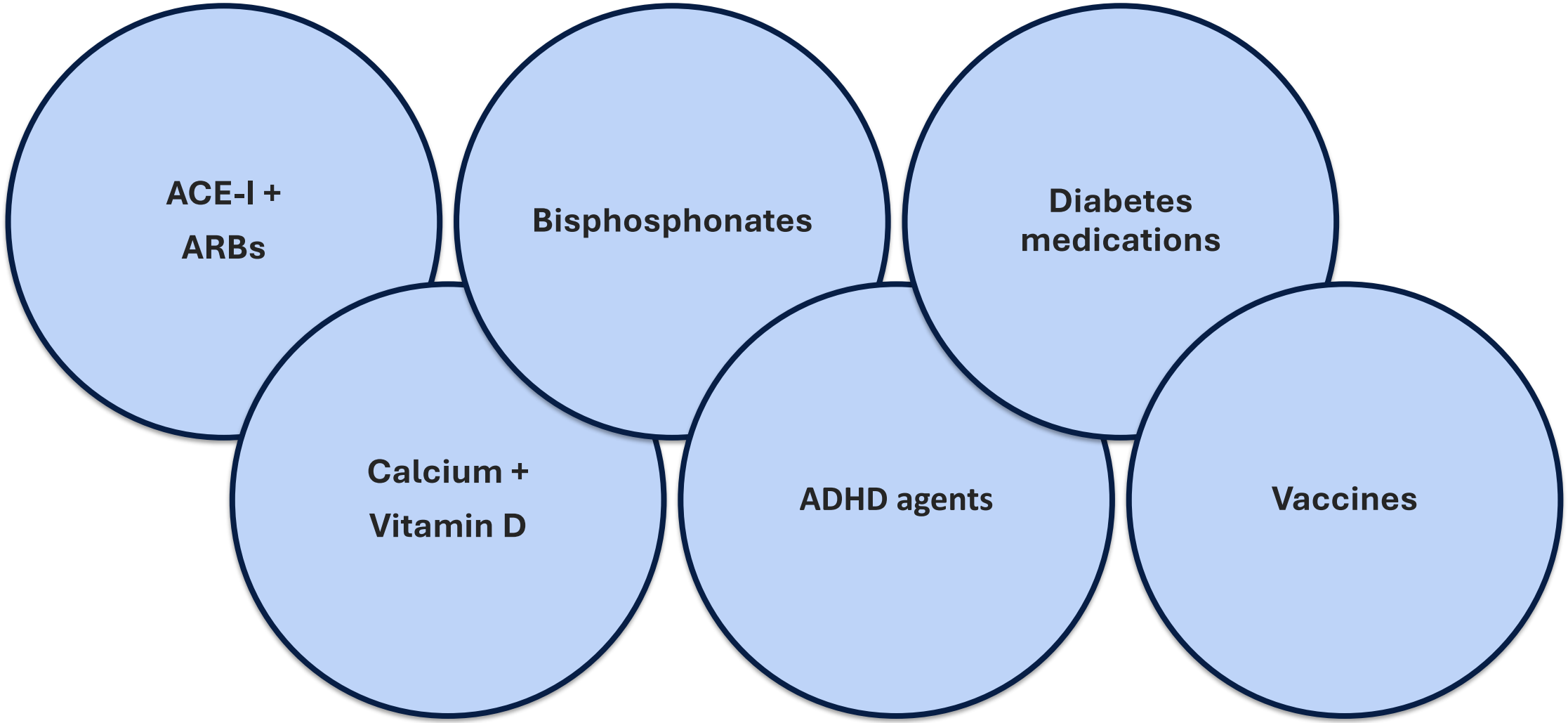
Pharmacy Times. Expert pharmacists play crucial role in safe, effective Elevidys treatment in DMD. *Pharmacy Times*. Published October 28, 2024.

Pipeline Therapies

Treatment	Mechanism	Trial Data
DYNE-251	Antisense oligonucleotide	**Phase I/II DELIVER trial:** Mean dystrophin expression of 8.72% in treated patients
SGT-003	Gene therapy	**Phase I/II INSPIRE DUCHENNE trial:** 3 patients showed an average micro-dystrophin expression of 110%
RGX-202	Gene therapy	**Phase I/II AFFINITY DUCHENNE trial:** Displayed functional improvements after 9 months of therapy, including a 4-point NSAA gain
AOC 1044	Antisense oligonucleotide	**EXPLORE44 trial:** Mean dystrophin expression of 25% accompanied by an 80% average decrease in creatine kinase levels

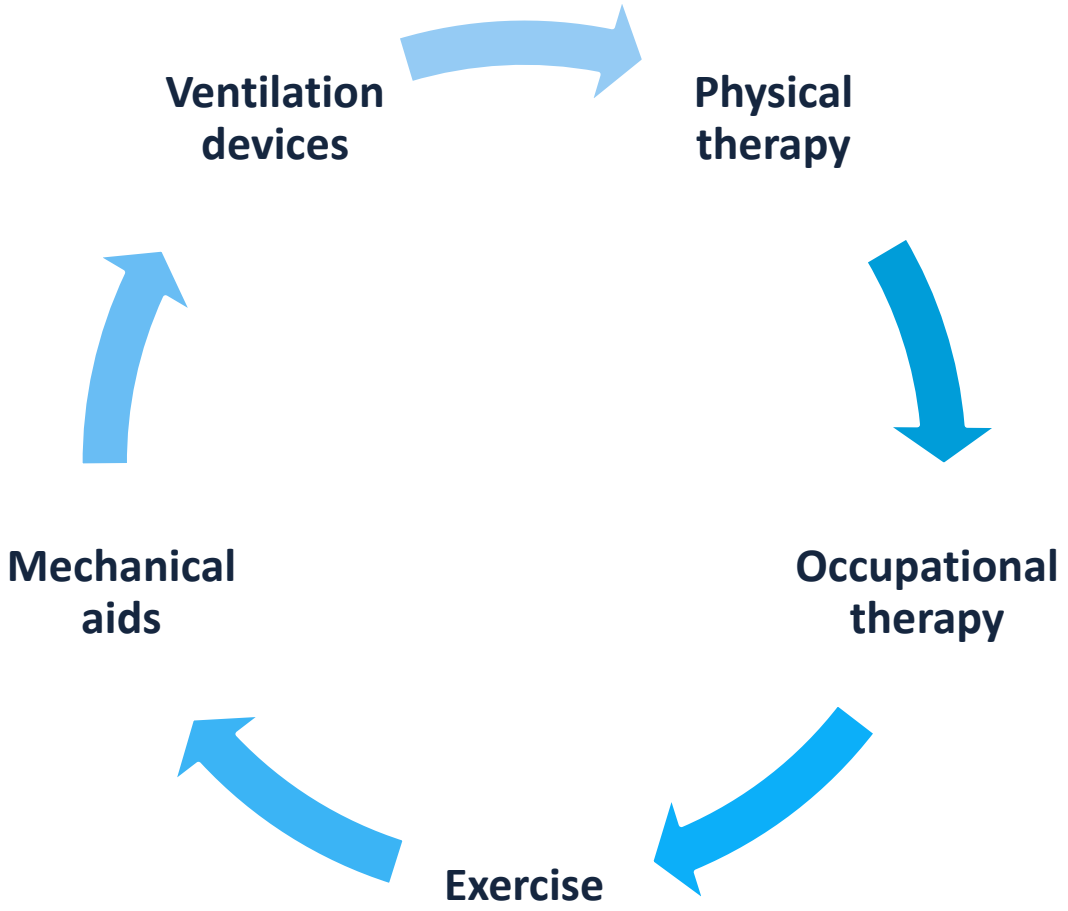
IPD Analytics. Duchenne muscular dystrophy pipeline. IPD Analytics website.

Additional Therapies



Birnkrant DJ, Bushby K, Bann CM, et al. Diagnosis and management of Duchenne muscular dystrophy, part 2: respiratory, cardiac, bone health, and orthopaedic management. *Lancet Neurol*. 2018;17(4):347-361. doi:10.1016/S1474-4422(18)30025-5

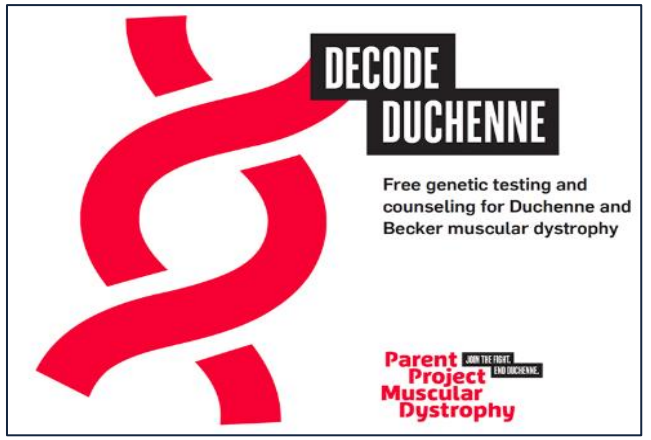
Supportive Therapies and Specialists



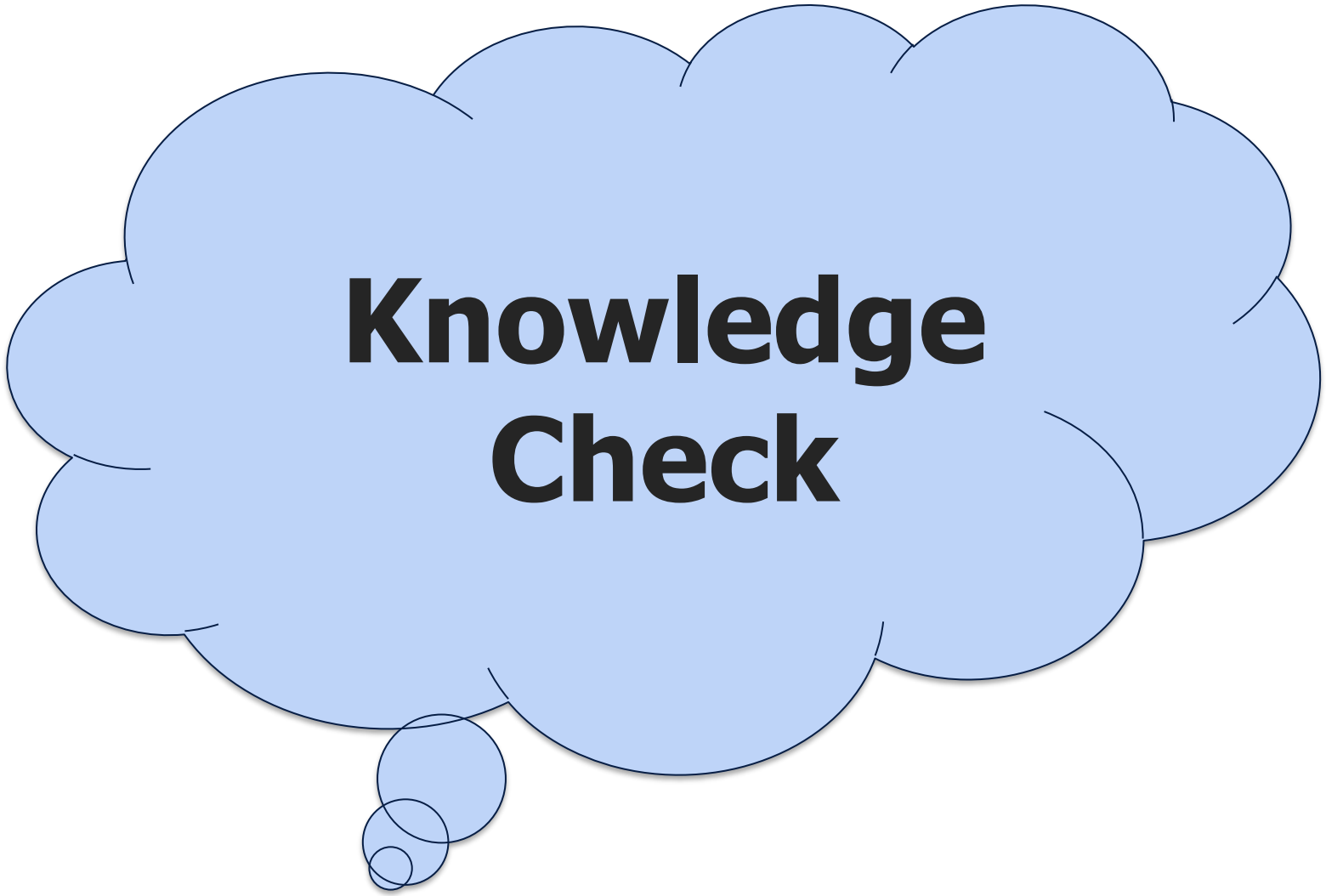
- Pulmonologists
- Physical/occupational therapists
- Orthopedists
- Cardiologists

Birnkrant DJ, Bushby K, Bann CM, et al. Diagnosis and management of Duchenne muscular dystrophy, part 2: respiratory, cardiac, bone health, and orthopaedic management. *Lancet Neurol.* 2018;17(4):347-361. doi:10.1016/S1474-4422(18)30025-5

Patient Resources

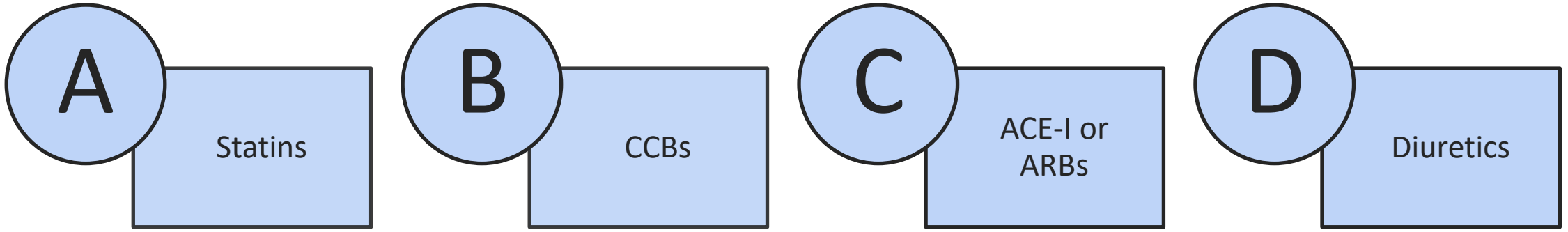


Decode duchenne program. Parent Project Muscular Dystrophy.
MDA community support groups. Muscular Dystrophy Association.
Duchenne muscular dystrophy - PAM Foundation.



Knowledge Check

Which class of medications is often used first-line to delay the progression of DMD-related cardiomyopathy?



CCBs = Calcium channel blockers
ACE-I = Angiotensin converting enzyme inhibitors
ARB = Angiotensin II receptor blockers

Knowledge Check

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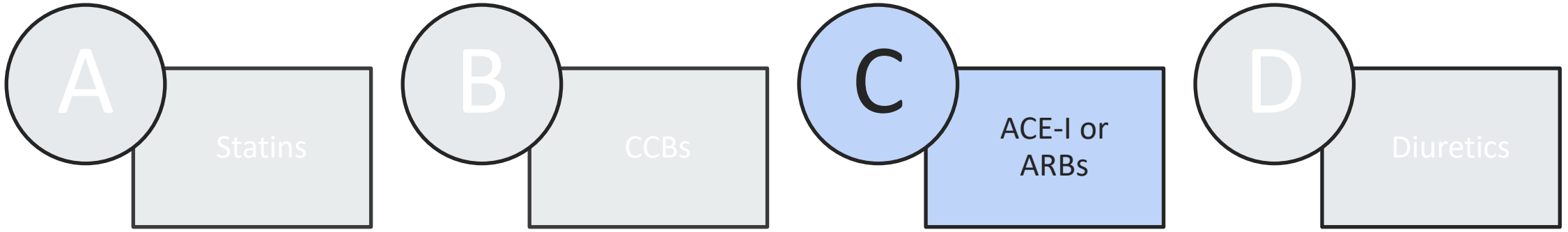

CCBs = Calcium channel blockers
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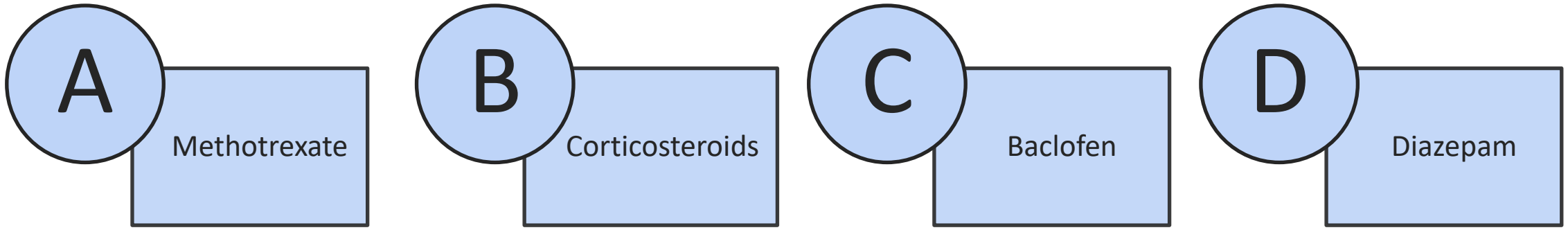
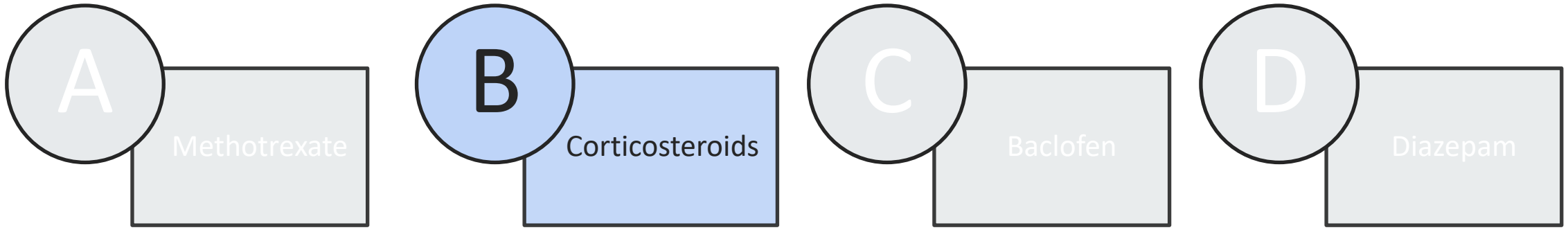
Knowledge Check

Which of the following is one of the standard pharmacologic treatments used to slow progression of DMD?



Knowledge Check

Which of the following is one of the standard pharmacologic treatments used to slow progression of DMD?



Key Takeaways

DMD is caused by mutations in the dystrophin gene and is characterized by progressive muscle weakness

Symptoms include ambulation difficulties, frequent contractures, respiratory and cardiac complications

Treatment options consist of corticosteroids, givinostat, delandistrogene moxeparvovec and exon skipping therapies

Supportive therapies play a large role in the management of DMD

References

1. Nordrum A. BioMarin's big bet: FDA weighs approval of potential blockbuster, first drug for fatal muscular disorder. International Business Times. December 31, 2015.
2. Duan D, Goemans N, Takeda S, Mercuri E, Aartsma-Rus A. Duchenne muscular dystrophy. *Nat Rev Dis Primers*. 2021;7(1):13. Published 2021 Feb 18. doi:10.1038/s41572-021-00248-3
3. Bez Batti Angulski A, Hosny N, Cohen H, et al. Duchenne muscular dystrophy: disease mechanism and therapeutic strategies. *Front Physiol*. 2023;14:1183101. Published 2023 Jun 26. doi:10.3389/fphys.2023.1183101
4. Venugopal V, Pavlakis S. Duchenne Muscular Dystrophy. [Updated 2023 Jul 10]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan.
5. Broomfield J, Hill M, Guglieri M, Crowther M, Abrams K. Life Expectancy in Duchenne Muscular Dystrophy: Reproduced Individual Patient Data Meta-analysis. *Neurology*. 2021;97(23):e2304-e2314. doi:10.1212/WNL.0000000000012910
6. Shrestha S, Munakomi S. Gower Sign. [Updated 2023 Feb 13]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan.
7. Kliegman RM. Duchenne Muscular Dystrophy: Workup. Medscape. Updated July 24, 2023.
8. Parent Project Muscular Dystrophy. Genetic testing for Duchenne.
9. Mah JK. Therapeutic options for Duchenne muscular dystrophy: hope or hype?. *Ther Adv Neurol Disord*. 2025;18:17562864251346326. Published 2025 Jun 21. doi:10.1177/17562864251346326
10. Parent Project Muscular Dystrophy. Imperatives for Duchenne Muscular Dystrophy. Published April 2018.
11. TREAT-NMD. Duchenne Muscular Dystrophy Care Guide.
12. US Food and Drug Administration. Kalydeco (ivacaftor) [package insert]. Silver Spring, MD: US Food and Drug Administration; January 2012.
13. Parent Project Muscular Dystrophy. PJ Nicholoff Steroid Protocol. Published March 2018.
14. Quattrocelli M, Zelikovich AS, Salamone IM, Fischer JA, McNally EM. Mechanisms and clinical applications of glucocorticoid steroids in muscular dystrophy. *J Neuromuscul Dis.* 2021;8(1):1-15. doi:10.3233/JND-200556.
15. Matthews E, Brassington R, Kuntzer T, Jichi F, Manzur AY. Corticosteroids for the treatment of Duchenne muscular dystrophy. *Cochrane Database Syst Rev*. 2016;2016(5):CD003725. Published 2016 May 5. doi:10.1002/14651858.CD003725.pub4
16. US Food and Drug Administration. Emflaza (deflazacort) [package insert]. Silver Spring, MD: US Food and Drug Administration; February 2017.
17. Griggs RC, Miller JP, Greenberg CR, et al. Efficacy and safety of deflazacort vs prednisone and placebo for Duchenne muscular dystrophy. *Neurology*. 2016;87(20):2123-2131. doi:10.1212/WNL.0000000000003217
18. US Food and Drug Administration. Elevidys (delandistrogene moxeparvovec-rokl) [package insert]. Silver Spring, MD: US Food and Drug Administration; June 2023.
19. Guglieri M, Clemens PR, Perlman SJ, et al. Efficacy and Safety of Vamorolone vs Placebo and Prednisone Among Boys With Duchenne Muscular Dystrophy: A Randomized Clinical Trial. *JAMA Neurol*. 2022;79(10):1005-1014. doi:10.1001/jamaneurol.2022.2480
20. Zulfiqar E, Hurjkaliani S, Umar SA, et al. Comparing intermittent and daily prednisone in duchenne muscular dystrophy: a systematic review and meta-analysis. *Ann Med Surg (Lond)*. 2025;87(3):1637-1645. Published 2025 Feb 27. doi:10.1097/MS9.0000000000003049
21. Hodgens A, Sharman T. Corticosteroids. [Updated 2023 May 1]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan.
22. Parent Project Muscular Dystrophy. Chronic Steroid Side Effects. Published March 2018.
23. Parent Project Muscular Dystrophy. Steroid care guidelines for Duchenne.
24. US Food and Drug Administration. Viltepso (viltolarsen) [package insert]. Silver Spring, MD: US Food and Drug Administration; August 2021.
25. US Food and Drug Administration. Vyondys 53 (golodirsen) [package insert]. Silver Spring, MD: US Food and Drug Administration; December 2019.
26. US Food and Drug Administration. Exondys 51 (eteplirsen) [package insert]. Silver Spring, MD: US Food and Drug Administration; September 2016.
27. US Food and Drug Administration. Amondys 45 (casimersen) [package insert]. Silver Spring, MD: US Food and Drug Administration; February 2021.
28. Echigoya Y, Lim KRQ, Nakamura A, Yokota T. Multiple Exon Skipping in the Duchenne Muscular Dystrophy Hot Spots: Prospects and Challenges. *J Pers Med*. 2018;8(4):41. Published 2018 Dec 7. doi:10.3390/jpm804004

References

29. Clemens PR, Rao VK, Connolly AM, et al. Efficacy and Safety of Viltolarsen in Boys With Duchenne Muscular Dystrophy: Results From the Phase 2, Open-Label, 4-Year Extension Study. *J Neuromuscul Dis*. 2023;10(3):439-447. doi:10.3233/JND-221656
30. A Study to Evaluate SRP-9001 in Duchenne Muscular Dystrophy (NCT04060199). Bethesda, MD: US National Library of Medicine; First posted August 16, 2019. Updated October 28, 2025.
31. Al-Zaidy SA, Rodino-Klapac LR, Mendell JR. Gene therapy for Duchenne muscular dystrophy: Clinical trials and outlook. *MedComm*. 2024;5(3):e362. doi:10.1016/j.medj.2024.100362.
32. US Food and Drug Administration. Duvyzat (givinostat) [package insert]. Silver Spring, MD: US Food and Drug Administration; March 2024.
33. Italfarmaco S.p.A. How Duvyzat works. Duvyzat HCP website.
34. A Study to Evaluate the Safety, Tolerability, and Efficacy of Golodirsen in Patients With Duchenne Muscular Dystrophy (NCT02851797). Bethesda, MD: US National Library of Medicine; First posted August 2, 2016. Updated October 28, 2025.
35. Syed N, Un Nisa Mughal Z, Haseeb A, Alemam Manhal G, Yasir Eissa A, Abbasher Hussien Mohamed Ahmed K. Duvyzat (givinostat): a new hope for Duchenne muscular dystrophy patients. *Ann Med Surg (Lond)*. 2025;87(5):2529-2531. Published 2025 Mar 28. doi:10.1097/MS9.0000000000003196
36. Italfarmaco Therapeutics. Duvyzat (givinostat) [prescribing information]. Boston, MA: Italfarmaco Therapeutics; 2024.
37. Italfarmaco S.p.A. Dosing and monitoring for Duvyzat. Duvyzat website.
38. Sarepta Therapeutics, Inc. Elevidys (delandistrogene moxeparvovec-rokl) [prescribing information]. Cambridge, MA: Sarepta Therapeutics, Inc.; 2023.
39. Hodgens A, Sharman T. Corticosteroids. [Updated 2023 May 1]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan.
40. Mendell JR, Muntoni F, McDonald CM, et al. AAV gene therapy for Duchenne muscular dystrophy: the EMBARK phase 3 randomized trial. *Nat Med*. 2025;31(1):332-341. doi:10.1038/s41591-024-03304-z
41. Naota M, Nozaki Y, Mikashima F, Higashiyama G. Key considerations for dose selection in first-in-human studies of cell and gene therapy products. *Cytotherapy*. 2025;27(11):1271-1278. doi:10.1016/j.jcyt.2025.06.012.
42. Allucent. Dose selection for cellular and gene therapies. Allucent website. Published July 11, 2023.
43. Sarepta Therapeutics, Inc. North Star Ambulatory Assessment (NSAA) fact sheet. Cambridge, MA: Sarepta Therapeutics, Inc.; April 2021.
44. Pharmacy Times. Expert pharmacists play crucial role in safe, effective Elevidys treatment in DMD. *Pharmacy Times*. Published October 28, 2024.
45. IPD Analytics. Duchenne muscular dystrophy pipeline. IPD Analytics website.
46. Parent Project Muscular Dystrophy. Vaccination recommendations. Parent Project Muscular Dystrophy website.
47. Landfeldt E, Phung K, Zaman F, et al. Bisphosphonates in Glucocorticoid-Treated Patients With Duchenne Muscular Dystrophy: A Systematic Review and Grading of the Evidence. *Neurology*. 2024;102(2):e207948. doi:10.1212/WNL.0000000000207948
48. Goldman V, Ryabets-Lienhard A, Howard L, et al. Obesity Management in Youth with Duchenne Muscular Dystrophy: A Review of Metformin and Alternative Pharmacotherapies. *Child Obes*. 2025;21(2):103-112. doi:10.1089/chi.2024.0297
49. Parent Project Muscular Dystrophy. Attention deficit hyperactivity disorder (ADHD). Parent Project Muscular Dystrophy website.
50. Lionarons JM, Hellebrekers DMJ, Klinkenberg S, Faber CG, Vles JSH, Hendriksen JGM. Methylphenidate use in males with Duchenne muscular dystrophy and a comorbid attention-deficit hyperactivity disorder. *Eur J Paediatr Neurol*. 2019;23(1):152-157. doi:10.1016/j.ejpn.2018.09.005
51. Birnkrant DJ, Bushby K, Bann CM, et al. Diagnosis and management of Duchenne muscular dystrophy, part 2: respiratory, cardiac, bone health, and orthopaedic management. *Lancet Neurol*. 2018;17(4):347-361. doi:10.1016/S1474-4422(18)30025-5
52. Decode duchenne program. Parent Project Muscular Dystrophy.
53. MDA community support groups. Muscular Dystrophy Association.
54. Duchenne muscular dystrophy - PAM Foundation.

Questions?

If you have any additional questions, please reach out to Karina Pelejo

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