

FLEX CEUs



Muscular Dystrophy



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Introduction

Muscular dystrophy (MD) encompasses an array of genetic disorders marked by progressive muscle weakness and degeneration. This course will review various types of muscular dystrophy, like Duchenne, Becker, Limb-Girdle, Facioscapulohumeral, and Myotonic dystrophies, among others. Each subtype presents distinctive inheritance patterns, clinical manifestations, and affected muscle groups, necessitating customized approaches to assessment and intervention. The course will encompass details on diagnosis, treatment modalities, development of individualized care plans, management of mobility challenges, impacted body systems, and the disease's implications on daily living. Upon course completion, PTs and PTAs will possess the knowledge and skills requisite for formulating tailored care plans for individuals with muscular dystrophy. Physical therapy care is designed to address the unique needs, goals, and disease progression of each patient, empowering practitioners to facilitate optimal outcomes and enhance quality of life.

Background on Muscular Dystrophy

Muscular dystrophy (MD) is a group of genetic disorders, characterized by progressive muscle weakness and degeneration. It poses profound challenges to affected individuals and the healthcare community at large. To effectively confront this condition, a thorough exploration of its background, types, encompassing etiology, pathophysiology, and clinical variability, is essential.

What is Muscular Dystrophy? ^{1,2}

Muscular dystrophy (MD) is a heterogeneous group of genetic disorders characterized by progressive and irreversible degeneration of skeletal muscles,

leading to muscle weakness, atrophy and functional impairment. This condition primarily affects the voluntary skeletal muscles responsible for movement. At the molecular level, MD arises from mutations in genes encoding structural and regulatory proteins essential for maintaining the integrity and function of muscle fibers. These genetic aberrations disrupt the intricate balance of muscle metabolism, contraction, and repair mechanisms, resulting in the destabilization and destruction of muscle cells. The most notable protein affected in many forms of MD is dystrophin, a critical component of the dystrophin-glycoprotein complex (DGC) that provides structural support to muscle fibers during contraction and relaxation. Mutations in the dystrophin gene, as seen in Duchenne and Becker muscular dystrophies, compromise the stability of the sarcolemma (the membrane surrounding muscle fibers), leading to increased susceptibility to damage and subsequent degeneration.

Clinically, MD manifests with variable age of onset, severity, and progression, depending on the specific genetic mutation and subtype. Some forms, like Duchenne muscular dystrophy (DMD), typically present in early childhood with rapidly progressive muscle weakness, loss of ambulation, and cardiopulmonary complications, leading to significant disability and reduced life expectancy. In contrast, other forms, like Limb-Girdle muscular dystrophy (LGMD), may have a later onset, milder course, and more variable clinical features, including proximal muscle weakness, exercise intolerance, and respiratory involvement.

While there is currently no cure for MD, multidisciplinary management approaches aim to alleviate symptoms, preserve muscle function, and improve quality of life. Physical therapy, occupational therapy, and respiratory therapy, plays a pivotal role in maintaining mobility, preventing contractures, optimizing respiratory function, and enhancing overall functional independence.

Understanding the various types of muscular dystrophy is essential for clinicians, as each subtype presents unique clinical features, genetic mutations and prognostic implications. From the devastating Duchenne muscular dystrophy, affecting primarily young boys, to the more idle Facioscapulohumeral muscular dystrophy, manifesting in adulthood, each subtype offers valuable insights into the underlying pathophysiology and therapeutic approaches. The next few sections will delve into the complexities of each type of muscular dystrophy, shedding light on their etiology, symptoms, genetic inheritance factors, clinical manifestations, and prognostic factors, with the overarching goal of advancing understanding and management of these debilitating conditions.

Duchenne Muscular Dystrophy (DMD) ³⁻⁷

Duchenne muscular dystrophy stands as one of the most severe and devastating forms of muscular dystrophy. It is characterized by progressive muscle weakness, degeneration, and eventual loss of ambulation, typically affecting boys in early childhood.

Etiology

DMD is caused by mutations in the DMD gene, located on the X chromosome (Xp21.2). The DMD gene is one of the largest genes in the human genome, consisting of 79 exons that span over 2.2 million base pairs of DNA. Mutations in any of these exons can disrupt the production of functional dystrophin protein. Without functional dystrophin, muscle fibers become fragile and prone to damage, initiating a cascade of muscle degeneration. The most common type of mutation in the DMD gene is large deletions or duplications of one or more exons. These deletions or duplications disrupt the reading frame of the gene, leading to the production of a non-functional or truncated dystrophin protein. Other types of mutations in the DMD gene include point mutations (single base changes),

insertions, or small deletions, which can also impair the production or function of dystrophin. Dystrophin is a critical protein that helps stabilize the muscle cell membrane during muscle contraction and relaxation. It forms part of a complex protein assembly known as the dystrophin-associated glycoprotein complex (DGC). In individuals with DMD, mutations in the DMD gene result in the absence or severe deficiency of dystrophin. Without sufficient dystrophin, muscle fibers become fragile and susceptible to damage during muscle contraction, leading to progressive muscle degeneration.

Duchenne muscular dystrophy is caused by mutations in the DMD gene, leading to the absence or deficiency of the dystrophin protein. These mutations disrupt the structural integrity of muscle fibers, resulting in progressive muscle weakness and degeneration. The X-linked recessive pattern of inheritance contributes to the prevalence and inheritance pattern of DMD in affected families, which will be explored further later in this section.

Symptoms

Symptoms of DMD typically become apparent between the ages of 3 and 5 years. Early signs may include delayed motor milestones, such as difficulty walking or climbing stairs, frequent falls, and Gower's sign. Gower's sign is a characteristic way of rising from the floor by pushing up with the hands due to weak hip muscles. As the disease progresses, muscle weakness becomes more pronounced, affecting proximal muscles first and then extending to distal muscles. Calf pseudohypertrophy, where the calf muscles appear enlarged due to fatty infiltration, is a hallmark feature. Additionally, individuals may develop contractures, scoliosis, and respiratory complications such as reduced lung function and difficulty breathing.

Gower's Sign



<https://nabilebraheim.mystrkingly.com/blog/gowers-sign>

Calf Pseudohypertrophy



https://www.researchgate.net/figure/Nine-year-old-boy-with-DMD-demonstrating-characteristic-calf-hypertrophy-Courtesy-of_fig1_221742748

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Cognitive Challenges

While Duchenne muscular dystrophy primarily affects muscle function, it can also lead to cognitive challenges in some individuals. The following are detailed explanations of the cognitive challenges associated with DMD.

Executive Dysfunction

Executive functions encompass a range of cognitive processes involved in planning, organizing, problem-solving, and decision-making. Individuals with DMD may experience executive dysfunction, characterized by difficulties with attention, working memory, cognitive flexibility, and inhibition. Executive dysfunction can

impact academic performance, social interactions, and activities of daily living, leading to challenges in school, work, and independent living.

Learning Disabilities

Learning disabilities, like dyslexia, dyscalculia (trouble understanding arithmetic), and language processing disorders, are more prevalent in individuals with DMD compared to the general population. Learning disabilities can affect reading, writing, spelling, mathematics, and language comprehension, making academic achievement more challenging for individuals with DMD. Early identification and intervention are essential for addressing learning disabilities and providing appropriate support in educational settings.

Attention Deficit Hyperactivity Disorder (ADHD)

ADHD is a neurodevelopmental disorder characterized by difficulties with attention, hyperactivity, and impulsivity. Some individuals with DMD may exhibit symptoms of ADHD, including inattention, distractibility, restlessness, and impulsivity. ADHD symptoms can interfere with academic performance, social interactions, and behavior management, requiring strategies for accommodation and support.

Social and Emotional Challenges

Social and emotional challenges are common in individuals with DMD and may be exacerbated by cognitive difficulties. Difficulties with executive functions, learning, and attention can impact social skills, self-regulation, and emotional well-being. Individuals with DMD may experience social isolation, low self-esteem, anxiety, depression, and behavioral problems as a result of cognitive and emotional challenges.

Intellectual Disability

While most individuals with DMD have average or above-average intelligence, a small percentage may experience intellectual disability. Intellectual disability is characterized by significant limitations in intellectual functioning and adaptive behavior, impacting overall cognitive development and functioning. Intellectual disability in DMD may be associated with more severe forms of the disease, genetic factors, or comorbid conditions.

Cognitive Decline

As DMD progresses, some individuals may experience cognitive decline, characterized by worsening executive functions, memory deficits, and intellectual impairment. Cognitive decline in DMD may be associated with disease progression, corticosteroid treatment, respiratory insufficiency, cardiac complications, and other factors.

Prognosis

The prognosis for Duchenne muscular dystrophy is unfortunately grim. Most individuals with DMD lose the ability to walk independently by their early teens, typically between ages 10 and 12. Without intervention, progressive muscle weakness leads to wheelchair dependence by adolescence or early adulthood. Complications like cardiomyopathy and respiratory failure further impact prognosis, with most individuals succumbing to cardiac or respiratory complications by their late teens to early twenties. However, advances in medical management, including corticosteroid therapy, respiratory support, and cardiac monitoring, have extended life expectancy and improved quality of life for individuals with DMD in recent years. Lifespan can vary widely among individuals with DMD based on factors like the specific genetic mutation, extent of muscle involvement, presence of cardiac and respiratory complications, access to medical care and interventions, and overall management and support. Some individuals

with DMD may survive into their 30s, 40s, or even beyond, while others may have a shorter lifespan due to more severe disease progression and complications.

Genetic Inheritance

DMD follows an X-linked recessive pattern of inheritance, meaning the gene mutation is located on the X chromosome. As a result, DMD primarily affects males, who have one X chromosome and one Y chromosome. Females, with two X chromosomes, typically carry one normal and one mutated copy of the DMD gene and are considered carriers. While carriers may exhibit mild symptoms or be asymptomatic, they have a 50% chance of passing the mutated gene to their offspring. The following include the possible ways that DMD can be inherited.

Parental Carrier Status. In most cases, DMD occurs when a mother who carries the mutated DMD gene on one of her X chromosomes passes it on to her son. Fathers do not pass the X chromosome to their sons because they contribute a Y chromosome.

Carrier Mother. A woman who carries one copy of the mutated DMD gene on one of her X chromosomes is known as a carrier. Carriers of DMD usually do not exhibit symptoms of the disorder because they have a second normal copy of the gene on their other X chromosome.

Transmission to Sons. When a carrier mother has a son, there is a 50% chance that she will pass on the mutated X chromosome carrying the DMD gene to him. If the son inherits the mutated X chromosome, DMD will affect him. If he inherits the normal X chromosome from his mother, he will not have DMD, but he will be a carrier like his mother.

Transmission to Daughters. Daughters of carrier mothers have a 50% chance of inheriting the mutated X chromosome carrying the DMD gene. If a daughter inherits the mutated X chromosome from her carrier mother, she will also be a

carrier of DMD. However, carriers usually do not exhibit symptoms, or they may experience mild symptoms.

Father to Daughter Transmission. While rare, a father with DMD could pass on his X chromosome with the mutated DMD gene to his daughter. In such cases, the daughter would be a carrier of DMD like her mother.

Father to Son Transmission. DMD cannot be passed from a father to his son because sons inherit their Y chromosome from their father, not an X chromosome.

In summary, Duchenne muscular dystrophy is typically passed from carrier mothers to their sons. Daughters of carrier mothers have a 50% chance of being carriers themselves. Fathers with DMD do not pass the condition to their sons but may pass the carrier status to their daughters. Genetic counseling is recommended for families with a history of DMD to understand the risk of inheritance and make informed decisions about family planning.

Clinical Manifestations

Duchenne muscular dystrophy is characterized by a wide range of clinical manifestations that primarily affect the muscles, cardiovascular, and respiratory system. This section will provide a detailed explanation of the clinical presentations of DMD.

Muscle Weakness and Wasting

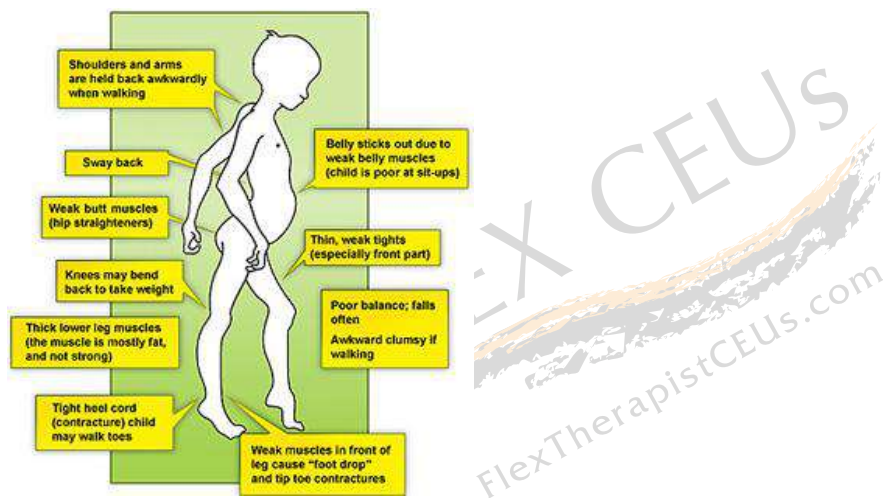
Progressive muscle weakness is the hallmark feature of DMD, which typically starts in early childhood, around ages 3 to 5. Initially, weakness affects the proximal muscles of the lower limbs, including the hip and thigh muscles. As the disease progresses, weakness extends to the pelvic girdle, shoulder girdle, and distal muscles of the arms and legs. Muscle wasting (atrophy) accompanies weakness and may be more evident in certain muscle groups, like the calves,

leading to calf pseudohypertrophy where the calf muscles appear enlarged due to fatty infiltration.

Gait Abnormalities

Children with DMD often exhibit a waddling or wide-based gait due to weakness in the hip and thigh muscles. As muscle weakness progresses, walking becomes increasingly difficult, and children may develop a characteristic pattern of walking on tiptoes to compensate for weak ankle dorsiflexors.

Gait Pattern and Contributing Factors in DMD



https://www.physio-pedia.com/Duchenne_Muscular_Dystrophy?utm_source=physio-pedia&utm_medium=search&utm_campaign=ongoing_internal

Difficulty Rising from the Floor

As previously mentioned, Gower's sign is a characteristic clinical finding in DMD. Children with DMD often have difficulty rising from the floor and use their hands to "walk" up their legs due to weak hip and thigh muscles.

Contractures and Joint Deformities

Progressive muscle weakness and imbalance can lead to contractures, where muscles and tendons become shortened and stiff, restricting joint movement. Common contractures in DMD include ankle contractures (equinus deformity),

knee contractures, and elbow contractures, which further impair mobility and function.

Cardiomyopathy

Cardiomyopathy, or weakening of the heart muscle, is a significant complication of DMD. It typically develops in the teenage years and progresses over time.

Symptoms of cardiomyopathy may include fatigue, shortness of breath, palpitations, and chest pain. Left untreated, cardiomyopathy can lead to heart failure and arrhythmias, significantly impacting prognosis.

Respiratory Complications

Respiratory muscle weakness is common in DMD and can lead to respiratory insufficiency and respiratory failure. Weakness of the diaphragm and intercostal muscles results in reduced lung volumes, ineffective cough, and impaired airway clearance, increasing the risk of respiratory infections and pneumonia.

Scoliosis and Spinal Deformities

Progressive muscle weakness and imbalance can lead to spinal curvature, known as scoliosis, in individuals with DMD. Spinal deformities may develop during childhood or adolescence and can cause pain, respiratory compromise, and functional impairment if left untreated. With DMD, muscle weakness tends to be more pronounced on one side of the body compared to the other. This asymmetry in muscle strength can contribute to the development of scoliosis, as weaker muscles are unable to counteract the forces exerted by stronger muscles on the opposite side of the spine. Asymmetric weakness may lead to uneven loading of the spine, causing it to curve laterally and resulting in the characteristic S-shaped or C-shaped curvature seen in scoliosis. Duchenne muscular dystrophy is a progressive condition, with muscle weakness worsening over time. As the disease advances, the risk of developing scoliosis increases. Scoliosis can exacerbate

respiratory complications associated with DMD. As the curvature of the spine increases, it can compress the thoracic cavity and restrict lung expansion, impairing respiratory function.

Becker Muscular Dystrophy 1,8,9

Becker muscular dystrophy is a genetic disorder characterized by mutations in the DMD gene, leading to reduced production of dystrophin. Symptoms vary widely but generally include progressive muscle weakness, gait abnormalities, and cardiac complications. The etiology, symptoms, prognosis, genetic components, and clinical manifestations will be explored in this section.

Etiology

Becker muscular dystrophy (BMD) is a genetic disorder caused by mutations in the DMD gene, located on the X chromosome. The DMD gene provides instructions for producing the dystrophin protein, essential for maintaining the structural integrity of muscle fibers. Mutations in the DMD gene result in reduced or abnormal production of dystrophin. Unlike Duchenne muscular dystrophy (DMD), where mutations lead to a complete absence of dystrophin, individuals with BMD produce some functional dystrophin, in reduced amounts. The severity of BMD is typically milder than DMD due to the presence of residual dystrophin.

Mutations in the DMD gene associated with BMD are typically missense mutations, nonsense mutations, small insertions, or deletions. Missense mutations alter a single nucleotide in the gene sequence, resulting in the production of a partially functional dystrophin protein. Nonsense mutations introduce a premature stop codon in the gene sequence, leading to the production of a truncated and non-functional dystrophin protein. Small insertions or deletions disrupt the reading frame of the gene, resulting in abnormal splicing

and production of an altered dystrophin protein. Mutations in the DMD gene in BMD result in reduced production or altered structure of dystrophin. While the exact mechanism varies depending on the specific mutation, the result is the production of a partially functional dystrophin protein that retains some ability to stabilize muscle fibers.

Symptoms

Becker muscular dystrophy (BMD) is characterized by a range of symptoms that primarily affect muscle function and may also involve other organ systems. This section will provide details on the symptoms of Becker muscular dystrophy.

Progressive muscle weakness is the hallmark feature of BMD, typically manifesting in childhood or adolescence. Muscle weakness, from proximal first to distal as it progresses, and muscle atrophy are hallmark symptoms. Individuals with BMD often experience gait abnormalities due to muscle weakness and imbalance. A waddling gait, lordotic posture (swayback), and difficulty with running, climbing stairs, and rising from a seated or lying position may be observed. Gait abnormalities may become more pronounced as muscle weakness progresses and may impact mobility and functional independence. Progressive muscle weakness and wasting in BMD can lead to the development of contractures, where muscles and tendons become shortened and stiff. People with BMD also will experience difficulty with breathing and cardiovascular complications. Other symptoms of BMD may include muscle cramps, stiffness, fatigue, and difficulty with fine motor tasks. Cognitive impairment and behavioral issues are less common in BMD compared to DMD but may occur in some individuals, particularly those with severe forms of the disease.

Prognosis

The prognosis of Becker muscular dystrophy (BMD) varies widely among affected individuals and depends on several factors, including the specific genetic mutation, extent of dystrophin production, presence of cardiac complications, and overall management and support.

Compared to Duchenne muscular dystrophy (DMD), individuals with BMD typically experience a milder clinical course due to the presence of residual dystrophin. The extent of dystrophin production in BMD varies among individuals, leading to variability in disease severity and progression. Some individuals may experience mild symptoms and minimal functional impairment, while others may have more significant muscle weakness, mobility limitations, and complications.

Prognosis depends on the impact of BMD on the cardiac and pulmonary systems. Cardiac complications are common in BMD and can significantly impact prognosis. Cardiomyopathy, characterized by weakening of the heart muscle, may develop later in life and progress slowly over time. Arrhythmias, such as atrial fibrillation, ventricular arrhythmias, and conduction abnormalities, may occur due to abnormalities in the heart's electrical conduction system. Early detection, monitoring, and management of cardiac complications are essential for optimizing outcomes and improving prognosis in BMD. Respiratory complications, including respiratory muscle weakness and respiratory insufficiency, can occur in BMD and may impact prognosis. Weakness of the diaphragm and intercostal muscles can lead to reduced lung volumes, ineffective cough, and impaired airway clearance. Respiratory complications may increase the risk of respiratory infections, pneumonia, and respiratory failure, particularly in individuals with advanced BMD. The average life expectancy of someone with BMD is 40-50 years, typically shortened due to cardiomyopathy.

With advancements in medical management and supportive care, individuals with BMD are living longer and enjoying improved quality of life compared to previous decades. Early diagnosis, multidisciplinary management, and supportive interventions, including physical therapy, orthopedic interventions, respiratory support, cardiac monitoring, and genetic counseling, can help optimize outcomes and enhance quality of life for individuals with BMD.

Genetic Inheritance

Becker muscular dystrophy (BMD) follows an X-linked recessive pattern of inheritance, which means it is caused by mutations in the DMD gene located on the X chromosome. There are a few possible factors involving the inheritance of BMD.

X-Linked Inheritance

The DMD gene is located on the X chromosome, one of the two sex chromosomes. Females have two X chromosomes (XX), while males have one X chromosome and one Y chromosome (XY). Since BMD is an X-linked disorder, it primarily affects males, who inherit one X chromosome from their mother and one Y chromosome from their father. Females can also be carriers of the mutated DMD gene if they inherit one normal X chromosome from one parent and one X chromosome carrying the mutation from the other parent. Carrier females typically do not exhibit symptoms of BMD but may have a 50% chance of passing the mutated gene to their offspring.

Transmission from Carrier Females

Carrier females have a 50% chance of passing the mutated DMD gene to each of their offspring, regardless of the child's sex. Sons who inherit the mutated gene will be affected by BMD. Since males have only one X chromosome, inheriting a single copy of the mutated gene is sufficient to cause the disorder. Daughters who

inherit the mutated gene from one parent will become carriers like their mother. They will have one normal X chromosome and one X chromosome carrying the mutation. Carrier females typically do not exhibit symptoms of BMD but may have a 50% chance of passing the mutated gene to their offspring.

Manifestation in Affected Males

Affected males with BMD inherit the mutated DMD gene from their carrier mother. Since males have only one X chromosome, they lack the protective effect of a second normal X chromosome. As a result, even a single mutated copy of the DMD gene is sufficient to cause BMD. Symptoms of BMD typically become apparent in childhood or adolescence and include progressive muscle weakness, difficulty walking, and other complications related to muscle degeneration.

Mutation Types

Mutations in the DMD gene associated with BMD can include deletions, duplications, point mutations, and other types of genetic changes. These mutations disrupt the production or function of dystrophin, a protein essential for maintaining the structural integrity of muscle fibers. The specific mutation type and its location within the DMD gene can influence the severity and progression of BMD symptoms.

Overall, Becker muscular dystrophy is inherited in an X-linked recessive manner, primarily affecting males who inherit a mutated copy of the DMD gene from their carrier mother. Carrier females have a 50% chance of passing the mutated gene to each of their offspring, regardless of their sex. Understanding the genetic basis of BMD is essential for accurate diagnosis, genetic counseling, and management of affected individuals and their families.

Clinical Manifestations

Becker muscular dystrophy (BMD) presents with a wide range of clinical manifestations that typically manifest gradually over time. This section explains the array of clinical presentation that a physical therapist or assistant may expect when working with patients with BMD.

Muscle Weakness and Fatigue

Muscle weakness tends to affect the proximal muscles of the hips and shoulders initially, including the hip flexors, hip extensors, and shoulder abductors.

Weakness may also involve other muscle groups, such as the proximal muscles of the arms and legs, albeit to a lesser extent than in Duchenne muscular dystrophy (DMD).

Gait Abnormalities

Gait abnormalities are common in individuals with BMD due to muscle weakness and imbalance. A waddling gait, lordotic posture (swayback), and difficulty with running, climbing stairs, and rising from a seated or lying position may be observed. Gait abnormalities may become more pronounced as muscle weakness progresses and may impact mobility and functional independence.

Muscle Wasting and Hypertrophy

Muscle wasting (atrophy) may occur in affected muscles over time, leading to a loss of muscle bulk and strength. The most common muscles to undergo atrophy are the hip flexors, hip extensors, shoulder abductors, and elbow flexors. Despite muscle wasting, some individuals with BMD may also exhibit compensatory muscle hypertrophy, particularly in certain muscle groups, as the body attempts to compensate for weakness. Muscles that play a significant role in maintaining posture and supporting body weight, such as the quadriceps, gluteal muscles, and paraspinal muscles, may undergo compensatory hypertrophy. Other muscles that

may undergo hypertrophy are the deltoids, biceps brachii, triceps brachii, gastrocnemius, and soleus.

Contractures and Joint Stiffness

Progressive muscle weakness and wasting in BMD can lead to the development of contractures, where muscles and tendons become shortened and stiff.

Contractures typically affect the joints of the lower limbs, including the hips, knees, and ankles, and may restrict joint movement and flexibility. Joint stiffness may contribute to gait abnormalities, difficulty with mobility, and impaired performance of activities of daily living.

Hip flexion contractures occur when the muscles and tendons around the hip joint become shortened and stiff, leading to limited extension of the hip. Individuals with BMD may develop hip flexion contractures due to weakness in the hip extensors (gluteus maximus) and compensatory tightening of the hip flexors (iliopsoas). Hip flexion contractures can result in a reduced ability to stand upright, walk efficiently, and perform activities that require hip extension, such as climbing stairs and rising from a seated position.

Knee flexion contractures involve the inability to fully extend the knee joint due to tightness in the muscles and soft tissues around the knee. Weakness in the quadriceps muscles, which are responsible for knee extension, combined with compensatory tightening of the hamstrings, can contribute to knee flexion contractures. Knee flexion contractures may lead to difficulty walking, limited stride length, and an abnormal gait pattern characterized by reduced knee extension during the swing phase of gait.

Ankle plantarflexion contractures occur when the muscles and tendons that control ankle movement become shortened and tight, resulting in a downward pointing of the foot. Weakness in the ankle dorsiflexors (tibialis anterior) and calf

muscles (gastrocnemius, soleus) may predispose individuals with BMD to develop ankle plantarflexion contractures. Ankle plantarflexion contractures impair walking, balance, and foot clearance during the swing phase of gait, increasing the risk of tripping and falling.

Contractures and stiffness may also occur in the upper limbs, particularly around the shoulder and elbow joints. Tightness in the muscles and soft tissues surrounding the shoulder joint can lead to limitations in shoulder abduction, flexion, and external rotation. Elbow contractures may result from tightness in the elbow flexors or extensors, restricting the range of motion and affecting functional activities such as reaching and grasping.

Cardiac Involvement

Cardiac complications are common in BMD and may include cardiomyopathy, arrhythmias, and heart failure. Cardiomyopathy, characterized by weakening of the heart muscle, may develop later in life and progress slowly over time. Arrhythmias, such as atrial fibrillation, ventricular arrhythmias, and conduction abnormalities, may occur due to abnormalities in the heart's electrical conduction system. Cardiac involvement may become unapparent until later in adolescence or adulthood and may require regular cardiac monitoring and intervention.

Respiratory Complications

Respiratory muscle weakness is a potential complication of BMD and may lead to respiratory insufficiency and respiratory failure. Weakness of the diaphragm and intercostal muscles can result in reduced lung volumes, ineffective cough, and impaired airway clearance. Respiratory complications may increase the risk of respiratory infections, pneumonia, and respiratory failure, particularly in individuals with advanced BMD.

Limb-Girdle Muscular Dystrophy (LGMD) ¹⁰⁻¹²

Limb-girdle muscular dystrophy (LGMD) comprises a group of genetic disorders characterized by progressive weakness and wasting of the muscles, particularly those around the shoulders and hips. This section will provide a detailed explanation of the etiology, symptoms, prognosis, genetic inheritance, and clinical manifestations of LGMD.

Etiology

Limb-girdle muscular dystrophy (LGMD) arises from genetic mutations that compromise the integrity and function of muscle fibers. This disorder encompasses over 30 different genes, each contributing to specific subtypes of LGMD. Mutations disrupt the production or function of proteins crucial for muscle stability, leading to progressive muscle degeneration and weakness. LGMD can be inherited in an autosomal dominant or autosomal recessive manner. In autosomal dominant LGMD, a single copy of the mutated gene from one parent is adequate to cause the disorder, exemplified by LGMD1A and LGMD1B linked to mutations in the MYOT and LMNA genes, respectively. Conversely, autosomal recessive LGMD necessitates two copies of the mutated gene, one from each parent, to manifest the disorder. Examples include LGMD2A, LGMD2B, and LGMD2C-F, resulting from mutations in genes such as CAPN3, DYSF, and SGCA-F, respectively. Genetic heterogeneity characterizes LGMD, with variations in genes encoding proteins governing muscle structure, membrane stability, and intracellular signaling contributing to diverse clinical presentations. The specific genetic mutation dictates the severity, onset age, progression rate, and pattern of muscle involvement. De novo mutations can also underlie LGMD, occurring spontaneously in individuals without a familial history of the disorder, further adding to its complexity. Understanding the genetic etiology of LGMD is pivotal for

accurate diagnosis, genetic counseling, and the development of targeted therapeutic approaches.

Symptoms

Limb-girdle muscular dystrophy (LGMD) is characterized by a spectrum of symptoms stemming from progressive muscle weakness and wasting. Individuals affected by LGMD typically experience weakness in the muscles around the shoulders and hips, often termed the limb-girdle muscles. Muscle weakness manifests gradually over time, commonly beginning in adolescence or early adulthood (age 20 to 30 is the most common onset age). Affected individuals may notice difficulty with tasks requiring muscle strength, such as lifting objects, climbing stairs, or rising from a seated position. As the disease progresses, weakness may extend to other muscle groups, leading to generalized muscle involvement. The severity and rate of progression of symptoms can vary widely among individuals and between different subtypes of LGMD. While some individuals may experience mild symptoms and maintain functional independence for many years, others may have a more rapid decline in muscle function, resulting in significant mobility limitations and functional impairment. Additionally, muscle weakness in LGMD may be asymmetric, with one side of the body more affected than the other. Overall, the hallmark symptom of LGMD is progressive muscle weakness, which can significantly impact mobility, activities of daily living, and quality of life. Early recognition of symptoms, accurate diagnosis, and comprehensive management are essential for optimizing outcomes and improving the quality of life for individuals with LGMD.

Prognosis

The prognosis for individuals with limb-girdle muscular dystrophy (LGMD) varies widely depending on several factors, including the specific subtype of LGMD, the

age of onset, the severity of symptoms, and the rate of disease progression. LGMD is a progressive disorder characterized by gradual muscle weakness and wasting over time. However, the rate of progression can vary significantly among affected individuals and between different subtypes of LGMD. Some individuals may experience a slow progression of symptoms, with periods of stability interspersed with periods of decline. Others may have a more rapid decline in muscle function, leading to significant mobility limitations and functional impairment. Despite the progressive nature of the disease, individuals with LGMD may maintain functional independence for many years, particularly with appropriate medical management and supportive care. Life expectancy is typically unaffected because cardiac and respiratory muscles are not affected. Advances in medical research and therapeutic interventions, such as physical therapy, orthopedic interventions, and respiratory support, have improved the prognosis and quality of life for individuals with LGMD. However, the long-term outlook can be challenging, and individuals with LGMD may require ongoing medical monitoring and multidisciplinary care to manage symptoms, optimize function, and address complications as they arise. Early diagnosis, genetic counseling, and access to specialized medical care are essential for individuals with LGMD to maximize their outcomes and quality of life.

Genetic Inheritance

Limb-girdle muscular dystrophy (LGMD) exhibits genetic inheritance patterns that vary depending on the specific subtype of the disorder. LGMD can be inherited in an autosomal dominant or autosomal recessive manner, with each mode of inheritance associated with distinct genetic mechanisms and implications for affected individuals and their families.

Autosomal dominant LGMD is characterized by the presence of a single mutated gene copy from one parent being sufficient to cause the disorder. Inheritance of the mutated gene from either the mother or the father can result in the

development of autosomal dominant LGMD in the offspring. Examples of autosomal dominant LGMD subtypes include LGMD1A and LGMD1B, caused by mutations in the MYOT and LMNA genes, respectively. Individuals with autosomal dominant LGMD have a 50% chance of passing the mutated gene on to each of their children, regardless of the sex of the parent or the child.

Conversely, autosomal recessive LGMD requires the presence of two mutated gene copies, one from each parent, for the disorder to manifest. If both parents carry a single mutated gene copy (referred to as carriers), they have a 25% chance with each pregnancy of having an affected child with autosomal recessive LGMD. Examples of autosomal recessive LGMD subtypes include LGMD2A (mutations in the CAPN3 gene) and LGMD2B (mutations in the DYSF gene). Carriers of autosomal recessive LGMD typically do not show symptoms of the disorder but have a 50% chance of passing the mutated gene on to their offspring.

Genetic testing and counseling are essential for individuals with LGMD and their families to understand the mode of inheritance, assess the risk of passing the disorder on to future generations, and make informed decisions about family planning. Additionally, genetic testing can aid in accurate diagnosis, subtype classification, and personalized management strategies for individuals with LGMD. A comprehensive understanding of the genetic basis of LGMD is crucial for healthcare providers to provide optimal care and support to affected individuals and their families.

Clinical Manifestations

Limb-girdle muscular dystrophy (LGMD) presents with a diverse array of clinical manifestations that primarily involve progressive muscle weakness and wasting, particularly in the muscles around the shoulders and hips. These manifestations can vary widely among individuals and between different subtypes of LGMD.

Muscle Weakness and Wasting

Progressive muscle weakness is the hallmark feature of LGMD, often beginning in adolescence or early adulthood. Weakness typically affects the proximal muscles of the shoulders and hips (the limb-girdle muscles) initially but may eventually involve muscles in other parts of the body. Muscle atrophy may accompany weakness, leading to a loss of muscle bulk and strength over time.

Difficulty with Mobility

Individuals with LGMD may experience difficulty with mobility and activities that require muscle strength, such as climbing stairs, lifting objects, and rising from a seated position. Gait abnormalities, such as a waddling gait or lordotic posture (swayback), may develop due to muscle weakness and imbalance.

Functional Limitations

Muscle weakness and wasting in LGMD can result in functional limitations that impact activities of daily living, including dressing, bathing, and grooming. Individuals may struggle with tasks requiring upper limb strength, such as reaching overhead or lifting objects.

Respiratory and Cardiac Complications

Some subtypes of LGMD may involve respiratory muscle weakness, leading to respiratory insufficiency and respiratory failure in severe cases. Weakness of the diaphragm and intercostal muscles can impair lung function and ventilation, potentially leading to respiratory infections and pneumonia. Certain subtypes of LGMD may be associated with cardiac complications, including cardiomyopathy and arrhythmias. Cardiomyopathy, characterized by weakening of the heart muscle, may develop over time and increase the risk of heart failure.

Joint Contractures and Stiffness

Contractures and joint stiffness may occur in individuals with LGMD, particularly in the hips, knees, and ankles. Muscle weakness and imbalance can lead to contractures, where muscles and tendons become shortened and stiff, restricting joint movement and flexibility.

Asymmetric Muscle Involvement

Muscle weakness in LGMD may be asymmetric, with one side of the body more affected than the other. Asymmetry in muscle involvement can contribute to uneven gait patterns and functional impairments.

Variable Disease Progression

The rate of disease progression in LGMD can vary widely among affected individuals and between different subtypes of the disorder. Some individuals may experience a slow progression of symptoms, while others may have a more rapid decline in muscle function and mobility.

Facioscapulohumeral Muscular Dystrophy (FSHD) ^{13,14}

Facioscapulohumeral muscular dystrophy (FSHD) is a genetic neuromuscular disorder characterized by progressive muscle weakness and wasting, primarily affecting the muscles of the face, shoulders, and upper arms. This section will provide an overview of FSHD, including its etiology, symptoms, prognosis, genetic inheritance, and clinical manifestations.

Etiology and Genetic Inheritance

Facioscapulohumeral muscular dystrophy primarily stems from genetic mutations that cause the abnormal activation of the DUX4 gene. The DUX4 gene is typically

inactive in healthy muscle cells, but in FSHD, mutations in specific regions of chromosome 4 lead to its inappropriate activation. This results in the production of the DUX4 harmful protein to muscle cells and leads to their degeneration.

The key genetic mutation involves a contraction of repetitive DNA sequences called D4Z4 repeats on chromosome 4. This contraction lowers the threshold for DUX4 gene activation. Additionally, epigenetic changes, which are modifications that affect how genes are expressed without altering the underlying DNA sequence, also play a role in regulating DUX4 expression.

The exact factors triggering the inappropriate activation of the DUX4 gene are still being studied, but these genetic and epigenetic changes collectively contribute to the development and progression of FSHD. Understanding these underlying mechanisms is vital for developing targeted treatments aimed at alleviating muscle degeneration and improving the quality of life for individuals with FSHD.

Symptoms and Clinical Manifestation

Facioscapulohumeral muscular dystrophy (FSHD) presents with a spectrum of symptoms primarily characterized by progressive muscle weakness and wasting, particularly affecting the face, shoulders, and upper arms. The following is an overview of the symptoms associated with FSHD.

Facial Weakness

FSHD often manifests with weakness in the facial muscles, resulting in difficulty with facial expressions. This can lead to a characteristic appearance described as a "smiling" or "pouting" expression due to the weakness of the muscles around the mouth.

Shoulder Weakness

One of the earliest signs of FSHD is weakness in the muscles around the scapulae. This weakness may cause difficulty with shoulder abduction and flexion, and the maintenance of those actions.

Upper Arm Weakness

Weakness in the upper arm muscles, particularly the deltoids and biceps, is common in individuals with FSHD. This can lead to challenges with tasks that involve lifting and carrying objects or reaching for items above shoulder level.

Scapular Winging

In some cases, weakness in the scapular stabilizers can result in scapular winging, where the edges of the shoulder blades protrude from the back. This can affect shoulder movement and stability.

Asymmetric Muscle Involvement

Muscle weakness in FSHD may be asymmetric, meaning that one side of the body may be more affected than the other. This asymmetry can contribute to uneven movement patterns and functional limitations.

Fatigue

Individuals with FSHD may experience increased fatigue, especially during activities that require muscle strength. This fatigue can exacerbate muscle weakness and impact overall function and quality of life.

Difficulty with Fine Motor Skills

Weakness in the muscles of the hands and fingers can lead to challenges with fine motor skills, such as writing, typing, and manipulating small objects.

Respiratory and Cardiac Complications

In some cases, FSHD may be associated with respiratory muscle weakness, leading to breathing difficulties and respiratory insufficiency, particularly during sleep or exertion. While less common, FSHD can occasionally affect the heart muscles, leading to cardiac complications such as cardiomyopathy or arrhythmias.

Progressive Nature

The symptoms of FSHD typically worsen over time, with progressive muscle weakness and wasting. However, the rate of progression can vary widely among affected individuals.

Overall, the symptoms of FSHD can significantly impact mobility, function, and quality of life. Early recognition of symptoms, accurate diagnosis, and comprehensive management strategies are essential for optimizing outcomes and improving the quality of life for individuals with FSHD.

Prognosis

The prognosis of Facioscapulohumeral Muscular Dystrophy (FSHD) varies widely among affected individuals due to differences in disease severity, progression, and associated complications. It does not typically affect the lifespan, unless under rare circumstances, the disease affects the cardiovascular or respiratory systems. However, due to FSHD being characterized by progressive muscle weakness and wasting, particularly in the muscles of the face, shoulders, and upper arms, it can lead to a degeneration of quality of life. Over time, this weakness can impact mobility, activities of daily living, and more. The rate of progression varies among individuals, with some experiencing slow deterioration while others may have a more rapid decline in muscle function. Early diagnosis, comprehensive medical management, and multidisciplinary care are essential for optimizing outcomes and improving the quality of life for individuals living with FSHD. Continued

research is needed to target treatment and improve prognostic factors, in quality of life, for those with FSHD.

Myotonic Dystrophy ¹⁵⁻¹⁷

Myotonic dystrophy (DM) is a genetic disorder that affects multiple body systems, characterized by muscle weakness, myotonia (prolonged muscle contractions), and a range of other symptoms. This section will cover the etiology, symptoms, prognosis, genetic inheritance information, and clinical manifestation of myotonic dystrophy.

Etiology

Myotonic dystrophy (DM), often referred to as Steinert's disease, is a genetic disorder characterized by muscle weakness and myotonia, a delayed relaxation of muscles after contraction. The etiology of myotonic dystrophy involves an expansion of repetitive DNA sequences in specific genes, leading to abnormal gene expression and subsequent cellular dysfunction. There are two main types of myotonic dystrophy, including type 1 (DM1) and type 2 (DM2). Each is associated with mutations in different genes.

Type 1 Myotonic Dystrophy (DM1) is caused by an expanded CTG trinucleotide repeat in the DMPK gene on chromosome 19. The DMPK gene normally encodes a protein called myotonic dystrophy protein kinase, which plays a role in muscle cell function. In DM1, the expanded CTG repeat leads to abnormal gene silencing and altered RNA processing, resulting in the accumulation of toxic RNA fragments called RNA foci. These RNA foci disrupt cellular processes and contribute to the characteristic features of DM1. Type 2 Myotonic Dystrophy (DM2) is caused by an expanded CCTG tetranucleotide repeat in the CNBP gene, also known as ZNF9, on chromosome 3. The CNBP gene encodes a protein called CCHC-type zinc finger,

nucleic acid binding protein (CNBP), which is involved in RNA metabolism. Similar to DM1, the expanded CCTG repeat in DM2 results in abnormal RNA processing and the formation of RNA foci, contributing to cellular dysfunction and muscle pathology.

Both DM1 and DM2 exhibit anticipation, a phenomenon where the severity of symptoms tends to increase and age of onset tends to decrease in successive generations. Additionally, the size of the expanded repeat often correlates with disease severity and age of onset, with larger repeat expansions associated with more severe symptoms and earlier onset.

Symptoms

Myotonic dystrophy (DM) manifests through an array of symptoms impacting various body systems. Characterized by progressive muscle weakness, individuals with DM often experience difficulty with everyday activities due to weakening of skeletal muscles, notably in the face, neck, arms, and legs. This muscle weakness is accompanied by myotonia, a condition marked by prolonged muscle contractions or challenges in relaxing muscles after contraction. Fatigue is a common symptom, often disproportionate to physical activity levels, while muscle stiffness can be particularly pronounced after periods of rest. Facial weakness may lead to distinctive facial expressions, while swallowing difficulties and speech problems arise from weakness in throat and facial muscles. Vision problems, such as cataracts or drooping eyelids, can also occur. Cardiac complications, including irregular heartbeats and weakening of the heart muscle, are prevalent, alongside respiratory issues stemming from weakened respiratory muscles. Cognitive impairment, with difficulties in concentration, memory, and executive functioning, may occur, especially in individuals with DM1. Endocrine abnormalities, such as insulin resistance and thyroid dysfunction, can further complicate the clinical picture. The severity and combination of symptoms vary widely among individuals

and can evolve over time, necessitating ongoing medical management and support.

Prognosis

The prognosis of myotonic dystrophy (DM) varies widely depending on the type of DM, the severity of symptoms, and the presence of associated complications. Myotonic dystrophy is a progressive condition, meaning symptoms tend to worsen over time. However, the rate of progression and the specific symptoms experienced can differ significantly among affected individuals. DM1 is typically more severe than DM2. Approximately one quarter of those with DM1 die prior to 18 months of age and half die before age 35. Lifespan is typically unaffected by DM2.

In both types of myotonic dystrophy (DM1 and DM2), muscle weakness and myotonia are characteristic features that can impact mobility, activities of daily living, and quality of life. As the disease progresses, individuals may experience increasing muscle weakness and fatigue, leading to greater difficulty with movement and functional limitations. Weakness in respiratory muscles can result in breathing difficulties, particularly during sleep or with exertion, and may increase the risk of respiratory infections. Cardiac complications, such as arrhythmias and cardiomyopathy, can also occur and may contribute to morbidity and mortality in some cases.

Cognitive impairment, including difficulties with concentration, memory, and executive functioning, is more commonly associated with DM1 and can vary in severity among affected individuals. Additionally, endocrine abnormalities, such as insulin resistance and thyroid dysfunction, may present further challenges for some individuals with myotonic dystrophy.

Despite the progressive nature of the disease, the prognosis for individuals with myotonic dystrophy can be variable. Some individuals may experience mild symptoms and maintain functional independence for many years, while others may have more severe symptoms and significant mobility limitations. Complications such as respiratory and cardiac issues can impact prognosis and may require medical intervention and management.

Genetic Inheritance

Myotonic dystrophy (DM) is an autosomal dominant genetic disorder, meaning a mutation in a single copy of the gene is sufficient to cause the condition. There are two main types of myotonic dystrophy, each associated with mutations in specific genes. Because myotonic dystrophy follows an autosomal dominant inheritance pattern, each child of an affected individual has a 50% chance of inheriting the mutated gene and developing the condition. However, the severity and age of onset of symptoms can vary widely among affected individuals, even within the same family, due to factors such as the size of the repeat expansion and genetic modifiers.

Congenital Muscular Dystrophy ^{2,18}

Congenital muscular dystrophy (CMD) is a group of genetic and present muscle disorders at birth or manifest early in infancy. Unlike some other forms of muscular dystrophy that may develop later in childhood or adulthood, CMD is characterized by muscle weakness and hypotonia (low muscle tone) that is apparent from birth or early infancy.

Etiology

Congenital muscular dystrophy (CMD) is primarily caused by genetic mutations that affect the structure or function of proteins essential for normal muscle development and function. The etiology of CMD varies depending on the specific subtype, with each subtype associated with mutations in different genes.

Merosin-Deficient Congenital Muscular Dystrophy (MDC1A) is caused by mutations in the LAMA2 gene, which encodes the protein merosin. Merosin is a crucial component of the extracellular matrix that surrounds muscle fibers and provides structural support. Mutations in the LAMA2 gene lead to a deficiency of merosin, resulting in weakened muscle fibers and impaired muscle function.

Ullrich Congenital Muscular Dystrophy (UCMD) is associated with mutations in genes encoding collagen VI proteins, including COL6A1, COL6A2, and COL6A3. Collagen VI is another component of the extracellular matrix that helps maintain muscle integrity and function. Mutations in COL6A1, COL6A2, or COL6A3 disrupt the production or function of collagen VI, leading to muscle weakness and other characteristic features of UCMD.

Walker-Warburg Syndrome (WWS) is caused by mutations in genes involved in the development of the brain and eyes, including POMT1, POMT2, POMGNT1, FKTN, FKRP, and others. These genes play essential roles in the glycosylation of critical proteins for normal brain and eye development. Mutations in these genes disrupt glycosylation processes, leading to brain malformations (lissencephaly, hydrocephalus) and eye abnormalities (congenital cataracts, glaucoma), in addition to muscle weakness characteristic of CMD.

Fukuyama Congenital Muscular Dystrophy (FCMD) is caused by mutations in the fukutin gene (FKTN). Fukutin is involved in the glycosylation of proteins and is necessary for normal muscle and brain development. Mutations in the FKTN gene

impair protein glycosylation, leading to muscle weakness and brain malformations (cobblestone lissencephaly) characteristic of FCMD.

Symptoms

Congenital muscular dystrophy (CMD) is characterized by a range of symptoms that typically manifest from birth or infancy. These symptoms can vary depending on the specific subtype of CMD and the severity of the condition. This section explains the main symptoms of CMD.

Muscle Weakness

Weakness of the skeletal muscles is a hallmark symptom of CMD. Infants with CMD may have difficulty lifting their heads, rolling over, or achieving motor milestones such as sitting, crawling, and walking. Muscle weakness can affect various muscle groups throughout the body, including the arms, legs, trunk, and facial muscles.

Hypotonia

Hypotonia, or low muscle tone, is commonly observed in infants with CMD. This can manifest as floppy or "ragdoll"-like movements, reduced resistance to passive movement, and poor head control.

Joint Contractures

Joint contractures, or stiffness in the joints, may develop due to muscle weakness and lack of mobility. Contractures can affect multiple joints, leading to limitations in range of motion and functional impairment.

Delayed Motor Development

Children with CMD often experience delays in achieving motor milestones such as sitting, crawling, standing, and walking. These delays are primarily due to muscle weakness and hypotonia.

Respiratory Difficulties

Some individuals with CMD may experience respiratory complications, such as weak respiratory muscles, reduced lung function, and an increased susceptibility to respiratory infections. Respiratory difficulties can range from mild to severe and may require respiratory support.

Feeding and Swallowing Difficulties

Weakness in the muscles involved in swallowing and feeding can lead to difficulties with breastfeeding, bottle-feeding, and transitioning to solid foods. Children with CMD may require specialized feeding techniques or interventions to ensure adequate nutrition and hydration.

Skeletal Abnormalities

Skeletal abnormalities, such as scoliosis, kyphosis, and joint deformities, may occur in some individuals with CMD. These abnormalities can exacerbate mobility issues and affect posture and overall function.

Intellectual and Developmental Disabilities

In some cases, individuals with CMD may experience intellectual and developmental disabilities, including cognitive impairment, learning difficulties, and behavioral challenges. These cognitive symptoms are more commonly associated with certain subtypes of CMD, such as Walker-Warburg syndrome and Fukuyama congenital muscular dystrophy.

Eye Abnormalities

Certain subtypes of CMD, such as Walker-Warburg syndrome and muscle-eye-brain disease, may be associated with eye abnormalities, including congenital cataracts, glaucoma, and retinal abnormalities.

Prognosis

As the treatment for most CMD disorders primarily involves supportive measures, prognosis is generally unfavorable. Life expectancy is dependent on the relationship between the genetic mutation and the resulting characteristics influenced by the abnormal protein. Respiratory or cardiac issues stemming from muscle weakness are the primary contributors to morbidity and mortality in these conditions.

Genetic Inheritance

Congenital muscular dystrophy (CMD) follows various inheritance patterns depending on the specific subtype. In many cases, CMD is inherited in an autosomal recessive manner, meaning that both parents must carry a mutation in the same gene for their child to be affected. Examples of CMD subtypes with autosomal recessive inheritance include some forms of collagen VI-related CMD (Ullrich congenital muscular dystrophy) and certain forms of laminin-related CMD (Merosin-deficient congenital muscular dystrophy).

In other cases, CMD may be inherited in an autosomal dominant manner, where only one copy of the mutated gene is sufficient to cause the disorder. In autosomal dominant inheritance, an affected individual has a 50% chance of passing the mutated gene on to each of their children. Examples of CMD subtypes with autosomal dominant inheritance include some forms of lamin A/C-related CMD.

There are also instances where CMD is caused by spontaneous mutations (de novo mutations) that occur in the affected individual and are uninherited from the parents. In such cases, the risk of recurrence in future pregnancies may be lower compared to inherited forms of CMD.

Prevalence ^{15,18-21}

The prevalence of muscular dystrophy varies depending on the specific type and geographic region. This section will provide an overview of the best estimates of prevalence of each subtype of muscular dystrophy.

Duchenne Muscular Dystrophy

DMD is one of the most common types of muscular dystrophy, affecting approximately 1 in every 3,500 to 5,000 male births worldwide. It primarily affects males due to its X-linked inheritance pattern.

Becker Muscular Dystrophy

BMD is less common than DMD and has a prevalence of approximately 1 in every 18,000 to 30,000 male births worldwide. It also primarily affects males due to its X-linked inheritance pattern.

Facioscapulohumeral Muscular Dystrophy

FSHD is estimated to affect 1 in every 8,000 to 20,000 individuals worldwide. It affects both males and females equally and can vary in severity among affected individuals.

Myotonic Dystrophy Type 1

DM1 is one of the most common adult-onset muscular dystrophies, with a prevalence of approximately 1 in every 8,000 to 20,000 individuals worldwide. It affects both males and females and can manifest at any age, with symptoms typically appearing in adulthood.

Myotonic Dystrophy Type 2

DM2 is less common than DM1, with a prevalence estimated to be lower than DM1 but still significant. It affects both males and females and typically manifests in adulthood, similar to DM1.

Limb-Girdle Muscular Dystrophy

LGMD encompasses a group of several subtypes, each with its own prevalence rate. Overall, LGMD is less common than some other forms of muscular dystrophy. Prevalence is estimated to be 1 in 50,000 people.

Congenital Muscular Dystrophy

CMD is a group of muscular dystrophies that are present at birth or manifest early in life. The prevalence of CMD varies depending on the specific subtype and can range from rare to more common, depending on geographic location and genetic factors. It is estimated that around 1 to 9 in 100,000 people are born with CMD.

It is important to note that these prevalence estimates are approximate and may vary based on factors such as diagnostic criteria, genetic testing availability, and regional differences in healthcare access and reporting. Additionally, ongoing research and advancements in genetic testing may lead to updates in prevalence estimates over time.

Pathophysiology ^{5,22}

The pathophysiological cascade in MD involves a complex interplay of inflammatory responses, oxidative stress, impaired calcium homeostasis, and aberrant signaling pathways, further exacerbating muscle damage and dysfunction. Progressive fibrosis, fatty infiltration, and replacement of muscle tissue with connective tissue contribute to the characteristic muscle wasting and weakness observed in affected individuals. This section will review genetic mutations, muscle fiber damage, inflammatory response, fibrosis and fat replacement, impaired regeneration, and systemic effects that occur from Muscular Dystrophy.

Genetic Mutations

As mentioned previously, muscular dystrophy is primarily caused by mutations in genes responsible for maintaining the structure and function of muscle cells. The type of MD often depends on the specific gene affected.

DMD is caused by mutations in the dystrophin gene. Dystrophin is crucial for maintaining the integrity of muscle fibers; its absence or dysfunction leads to muscle damage. BMD is caused by mutations in dystrophin, but it is partially functional, leading to a less severe phenotype. Each type of muscular dystrophy is associated with mutations in specific genes that encode proteins essential for muscle fiber function and integrity. For example, mutations in the genes for sarcoglycans or dysferlin are responsible for limb-girdle muscular dystrophy.

Muscle Fiber Damage

The absence or dysfunction of proteins like dystrophin compromises the stability of the muscle cell membrane (sarcolemma). The loss of membrane integrity due to insufficient dystrophin leads to an abnormal influx of calcium ions into muscle

cells. Elevated intracellular calcium activates calcium-dependent proteases (calpains), which degrade muscle proteins and promote apoptosis and necrosis. This damage is exacerbated by the mechanical stress of muscle contraction. Increased intracellular calcium can also impair mitochondrial function, leading to enhanced production of reactive oxygen species and further cellular damage.

Inflammatory Response

Damaged muscle cells release pro-inflammatory cytokines and chemokines, which recruit immune cells (macrophages, T-cells, neutrophils) to the site of injury. While initially beneficial for clearing cellular debris, prolonged inflammation can perpetuate muscle damage. Inflammatory cytokines activate fibroblasts, which produce collagen and other extracellular matrix components, leading to fibrosis. This fibrotic tissue impairs muscle elasticity and function.

Fibrosis and Fat Replacement

As muscle fibers degenerate, they are often replaced by connective tissue (fibrosis) and adipose tissue. This replacement not only reduces muscle function but also contributes to the stiffness and decreased elasticity of the muscles, leading to reduced mobility and contractures.

Impaired Regeneration

Satellite cells are muscle stem cells that reside between the basal lamina and the sarcolemma of muscle fibers. In muscular dystrophy, repeated cycles of muscle damage and regeneration exhaust these cells, or they may become dysfunctional, failing to proliferate or differentiate effectively into new muscle fibers. Myostatin, a negative regulator of muscle growth, has been found to be upregulated in muscular dystrophy. Elevated myostatin levels further inhibit muscle regeneration and growth.

Systemic Effects

Although muscular dystrophy primarily affects skeletal muscles, it can have systemic effects, especially in more severe forms like DMD. The primary systemic effects are within the cardiovascular, respiratory, skeletal, gastrointestinal, endocrine, and immune systems. Cardiomyopathy in muscular dystrophy often results from similar molecular disruptions in cardiac muscle cells. Respiratory muscle weakness due to diaphragmatic and intercostal muscle deterioration can lead to compromised pulmonary function. The progressive muscle weakness leads to changes in biomechanics and stress distribution, contributing to bone deformities like scoliosis. Another systemic effect is regarding smooth muscle of the digestive and urinary systems. MD can affect the gastrointestinal system and other internal organs. Those with MD may experience dysphagia due to muscle weakness in the muscles involved in swallowing. They also may experience gastrointestinal motility disorders due to the disruption of smooth muscle function. Some individuals may experience issues within their urinary system, such as incontinence or urinary retention. This is partly due to immobility and also possibly due to direct effects on smooth muscle function in the urinary tract. Growth impairment and delayed puberty is common in Duchenne muscular dystrophy, often exacerbated by chronic glucocorticoid therapy, which can also contribute to stunted growth. In addition, insulin resistance and type 2 diabetes is common, especially in myotonic dystrophy, where the disruption of cellular function extends to pancreatic cells, affecting insulin secretion and action. Due to compromised respiratory function and potential malnutrition from feeding difficulties, individuals with MD may be more susceptible to infections, impacting the immune system.

Understanding the pathophysiology of muscular dystrophy is crucial for developing therapeutic strategies for medical and physical therapy treatment. Current research focuses on genetic therapies, including gene replacement and

editing, as well as strategies to boost muscle regeneration and reduce inflammation.

Section 1 Key Words

X-Linked Inheritance - A method of passing a gene from parent to child where the trait of a disorder is found on the X chromosome

Limb Girdle Muscular Dystrophy - A type of muscular dystrophy that primarily impacts the strength of muscles in the extremities

Anticipation - A phenomenon where the presentation of a genetic condition exacerbates as the condition is passed on through generations

Myotonic Muscular Dystrophy - A type of muscular dystrophy with varying severity that causes muscles to weaken and break down easily and prevents muscles from relaxing voluntarily

Congenital Muscular Dystrophy - A variation of muscular dystrophy that presents in infancy rather than later in life

Section 1 Summary

Muscular dystrophy is a collection of genetic disorders marked by the gradual weakening and deterioration of muscles, presenting significant obstacles for affected individuals. This condition requires a comprehensive examination of its origins, various types, including their etiology, pathophysiology, prevalence, and clinical diversity. Such an in-depth understanding is vital for developing effective strategies to manage and alleviate the impact of muscular dystrophy on those affected and to advance treatments and interventions within the medical community.

Diagnosis and Progression

Diagnosing muscular dystrophy involves a multifaceted approach that considers various factors such as clinical presentation, genetic testing, and imaging studies. However, due its similarity to other neuromuscular conditions, differential diagnosis is crucial to accurately identify the specific subtype. Once diagnosed, understanding the progression of MD is vital as it varies widely among individuals, impacting mobility and overall quality of life differently. Mobility challenges arise as muscle weakness progresses, affecting activities of daily living and necessitating adaptive equipment or mobility aids. Furthermore, MD affects multiple body systems beyond the muscular system, including respiratory, cardiac, and skeletal systems, highlighting the need for comprehensive care and management strategies to address the diverse needs of individuals living with MD.

Medical Diagnosis ^{5,9,23,24}

Diagnosing muscular dystrophy (MD) involves a combination of clinical evaluation, family medical history, genetic testing, and various diagnostic tests to confirm the presence and type of muscular dystrophy.

Clinical Evaluation

The initial step of evaluation involves a detailed assessment of symptoms, such as muscle weakness, muscle wasting, difficulties in walking, frequent falls, and developmental delays in motor milestones. A physician will perform a thorough physical exam to evaluate muscle strength, reflexes, and the presence of muscle wasting or contractures. The Gowers' sign is one specific test often used to detect muscle weakness in Duchenne muscular dystrophy; it observes how a person rises from a lying or sitting position.

Family History

A detailed family history is taken to understand the inheritance pattern, which can often indicate the type of MD, as many forms are inherited in predictable patterns (such as X-linked for Duchenne and Becker muscular dystrophy).

Patterns of inheritance include X-linked inheritance, autosomal recessive inheritance, and autosomal dominant inheritance. X-linked inheritance is most notable in Duchenne and Becker muscular dystrophies. Since the dystrophin gene is located on the X chromosome, mothers can be carriers and pass the defective gene to their sons, who are affected by the disease. Daughters may become carriers like their mothers. Autosomal recessive inheritance is seen in some forms of limb-girdle muscular dystrophy and both parents must carry and pass on a copy of the defective gene for a child to be affected. Autosomal dominant inheritance occurs in facioscapulohumeral muscular dystrophy and some forms of limb-girdle muscular dystrophy. Here, only one parent needs to pass on the defective gene for the child to be affected.

Laboratory Tests

Tests for lab results that contribute to an MD diagnosis include creatine kinase levels, aldolase levels, liver enzymes, lactate dehydrogenase, and myoglobin.

Elevated levels of creatine kinase (CK), an enzyme that leaks out of damaged muscle, are often one of the first indicators of muscle damage. Extremely high CK levels are typically seen in conditions like Duchenne muscular dystrophy. CK levels can be 10 to 100 times the normal amount, even before significant muscle weakness becomes apparent. Aldolase is another enzyme that becomes elevated in the blood when muscle or liver tissue is damaged. Like CK, high levels of aldolase can support the diagnosis of muscular dystrophy or other muscle diseases. Aldolase plays a crucial role in glycolysis, the fundamental metabolic

pathway that converts glucose into pyruvate, generating energy in the form of ATP. Elevated liver enzymes may also be observed, secondary to muscle breakdown rather than liver disease. Elevated levels can occur when muscle damage releases these enzymes into the bloodstream. Lactate dehydrogenase (LDH) is an enzyme involved in energy production, found in all body tissues, including muscles. Elevated levels of LDH can indicate muscle damage among other conditions and are sometimes used to monitor the progression of disease in muscular dystrophy. Myoglobin is a protein that helps store oxygen in muscle cells, and it can be released into the bloodstream when muscle cells are damaged. Myoglobinuria occurs when elevated myoglobin levels can be detected in the urine and blood and serve as a marker of muscle injury. All of these levels can be monitored by blood samples and laboratory testing, assisting in the diagnosis of MD.

Genetic Testing

Genetic testing is essential for confirming the diagnosis of muscular dystrophy, identifying the specific mutation, and facilitating proper management and genetic counseling. Once muscular dystrophy is suspected based on clinical signs and family history, genetic testing is performed to identify specific mutations. This test can confirm the type of MD and guide treatment decisions. Genetic tests are crucial for confirming the diagnosis and identifying the specific mutation within a gene known to cause MD. DNA analysis is particularly definitive for conditions like Duchenne, where mutations in the dystrophin gene are the primary cause. Carrier testing is useful for family planning purposes. Genetic testing can also be used to identify carriers of the muscular dystrophy gene mutations, especially in diseases with a known X-linked inheritance pattern. For families with a known MD mutation, prenatal and preimplantation genetic diagnosis (PGD) offers options for assessing the genetic status of embryos or fetuses. This allows parents to make

informed decisions about family planning. Next-Generation Sequencing (NGS) enables the simultaneous testing of multiple genes, which is beneficial in conditions like limb-girdle muscular dystrophy where many different genes may be involved. It is more efficient and cost-effective, especially when the specific type of MD is not clear.

Muscle Biopsy

If genetic testing is inconclusive, a muscle biopsy might be performed to look for characteristic changes in muscle tissue that are indicative of MD. A muscle biopsy analyzes muscle tissue under a microscope, which can reveal characteristic changes in muscle fibers indicative of MD, such as replacement of muscle tissue with fat and connective tissue. Immunohistochemistry is a technique that can detect the presence and quantity of specific proteins (dystrophin in DMD) within the muscle cells, helping to diagnose the specific type of MD.

Imaging Studies

Muscle imaging, with MRI and ultrasound can be used to view the pattern of muscle involvement and replacement of muscle tissue with fat or fibrosis. MRI is particularly useful for assessing the extent and distribution of muscle damage and for monitoring disease progression.

Electrodiagnostic Tests

Electromyography (EMG) and nerve conduction studies (NCS) can also be part of the diagnostic evaluation, though they are unspecific for MD. EMG measures the electrical activity of muscle fibers and can help distinguish muscular dystrophy from nerve disorders or other muscle diseases that might cause similar symptoms. NCS assesses the health and function of motor and sensory nerves and can exclude other causes of muscle function loss.

Cardiac and Pulmonary Evaluation

Cardiovascular and pulmonary tests can be run to examine the extent of systemic involvement with muscular dystrophy. An echocardiogram may be performed to assess the health and function of the heart. A cardiac evaluation is useful for identifying cardiomyopathy or arrhythmias. Pulmonary function tests are performed to determine the extent of involvement of the respiratory system. These tests may include forced vital capacity, where the air that a person can forcibly exhale from their lungs after taking the deepest breath possible is measured and compared to normal standards. Another test is Forced Expiratory Volume in 1 second (FEV1), which measures how much air a person can exhale during the first second of the FVC test. The FEV1/FVC ratio is used to assess the presence of obstructive airway diseases, which can coexist or be misinterpreted in muscular dystrophy.

The combination of these diagnostic tools allows for a comprehensive assessment to confirm the diagnosis of muscular dystrophy and determine the specific type and severity of the disease. Genetic counseling is recommended following a diagnosis, to help affected individuals and their families understand the implications of the disease, potential treatments, and management strategies.

Clinical Differential Diagnosis ²⁵⁻²⁹

The differential diagnosis for muscular dystrophy involves considering a variety of conditions that can mimic the symptoms of muscular dystrophy, such as progressive muscle weakness and wasting. It is important for clinicians to differentiate these conditions to ensure appropriate management and treatment. This section will overview the major differential diagnoses that muscular dystrophy may be mistaken for.

Neuromuscular Junction Disorders

Neuromuscular junction disorders are a group of medical conditions that affect the neuromuscular junction, or the connection between neurons and the muscles they control. These disorders disrupt the transmission of nerve signals to muscles, impairing muscle function and leading to symptoms such as weakness and fatigue. Myasthenia Gravis is an example. It is an autoimmune disorder that affects the neuromuscular junction, leading to muscle weakness that typically improves with rest. Lambert-Eaton Myasthenic Syndrome is another example. It is characterized by muscle weakness of the limbs and often associated with small-cell lung cancer. Symptoms may improve with muscle use, contrasting with muscular dystrophy.

Motor Neuron Diseases

Motor neuron diseases (MNDs) are a group of progressive neurological disorders that affect the motor neurons, the cells in the central nervous system that control voluntary muscle activity. These diseases result in the degeneration and death of motor neurons, leading to muscle weakness and wasting. Amyotrophic Lateral Sclerosis (ALS), also known as Lou Gehrig's disease, involves the degeneration of motor neurons, leading to muscle weakness, atrophy, and spasticity. ALS affects both upper and lower motor neurons. Spinal Muscular Atrophy (SMA) is a genetic disorder that affects the motor neurons of the spinal cord, leading to muscle wasting and weakness. Unlike muscular dystrophy, SMA does not typically involve elevated muscle enzymes like CK.

Inflammatory Myopathies

Inflammatory myopathies are a group of diseases characterized by chronic inflammation of the muscles, which can lead to muscle weakness and damage. Polymyositis and dermatomyositis are autoimmune conditions characterized by inflammation and degeneration of muscle. They can cause muscle weakness and

elevation of muscle enzymes, similar to muscular dystrophy. Dermatomyositis also includes a skin rash, which can help distinguish it. Inclusion Body Myositis presents typically in older adults with a slow progression of muscle weakness, often more pronounced in the forearms and fingers.

Metabolic and Endocrine Disorders

Both hyperthyroidism and hypothyroidism can lead to muscle weakness. Other systemic symptoms and hormonal tests help in diagnosis. Mitochondrial myopathies are caused by defects in mitochondrial DNA that affect cellular energy production. They can present similarly to muscular dystrophy but often have additional features like seizures, stroke-like episodes, and lactic acidosis.

Congenital Myopathies

Congenital myopathies are a group of genetic muscle disorders that present at birth or in early infancy. They are characterized by structural abnormalities in the muscle fibers, which lead to muscle weakness, hypotonia, and sometimes delayed motor development. Unlike muscular dystrophies, which are marked by progressive muscle degeneration, congenital myopathies involve static or slowly progressive muscle issues. Nemaline myopathy is characterized by muscle weakness, usually starting in early childhood. Diagnosis is confirmed by the presence of specific rod-like structures in muscle fibers on biopsy. Central core disease often presents at birth with hypotonia and motor delays, with a characteristic appearance on muscle biopsy.

Toxic Myopathies

Toxic myopathy refers to muscle damage caused by exposure to certain chemicals, drugs, or other substances that directly or indirectly harm muscle tissue. This condition is characterized by muscle weakness, pain, cramps, and sometimes

significant muscle breakdown, which can lead to acute renal failure if severe. Alcohol Myopathy can occur due to acute and chronic alcohol misuse. It can lead to muscle weakness and atrophy. In addition, drug-induced myopathy is caused by various medications, including statins, corticosteroids, and colchicine. A history of drug exposure is crucial for diagnosis.

Genetic Disorders Mimicking Muscular Dystrophy

Several genetic disorders can present symptoms similar to those of muscular dystrophy, such as muscle weakness, wasting, and sometimes elevated muscle enzymes. It is crucial for clinicians to consider these conditions in the differential diagnosis to ensure accurate diagnosis and appropriate management. Charcot-Marie-Tooth Disease is a hereditary motor and sensory neuropathy leading to peripheral nerve degeneration and related muscle atrophy. Friedreich's Ataxia is an inherited disease that causes progressive damage to the nervous system and affects muscle coordination from the spinal cord and peripheral nerve degeneration. It presents progressive limb and gait ataxia, muscle weakness, and loss of reflexes.

Diagnostic Approach

The approach to diagnosing these conditions typically includes a detailed patient history, physical examination, laboratory testing (such as CK levels and antibodies), electromyography, muscle biopsies, genetic testing, and imaging studies like MRI. Each of these tools can provide valuable information that helps narrow down the differential diagnosis, ensuring that patients receive accurate diagnoses and appropriate management strategies.

Progression and Mobility Stages ^{5,6,10,17,19}

For a deeper look into the progression of various forms of muscular dystrophy, each subtype comes with its own specific patterns of symptom onset, progression rate, and potential complications. This section will overview the progression and mobility stages of DMD, BMD, myotonic, FSHD, and LGMD.

Duchenne Muscular Dystrophy (DMD)

Initial Symptoms appear in early childhood, between ages 2 and 5. The first signs often include difficulties with running, jumping, and frequent falls. Children may have trouble climbing stairs and rising from the floor (Gowers' sign, where a child uses their hands to "walk" up their legs to stand). At this stage, children are usually ambulatory but may begin to show a waddling gait and hypertrophy of calf muscles.

In late childhood, from ages 6-9, muscle weakness becomes more pronounced, especially in the proximal muscles of the legs and pelvis. This weakness leads to an increased difficulty with ambulation and maintaining balance. Children may start using mobility aids such as braces to support walking. They typically develop compensatory movements to manage muscle weakness, such as the Gowers' sign becoming more evident.

The pre-teen years (ages 10-12) are marked by the loss of ambulation. As muscle strength continues to decline, many children lose the ability to walk independently and may transition to using a wheelchair full-time. The use of a wheelchair can help maintain independence despite decreased lower limb strength. At this stage, preserving upper body strength becomes crucial for daily activities and wheelchair mobility.

Teenage years (ages 13-18) are marked by increased dependence. Along with the loss of ambulatory abilities, arm and trunk muscles weaken, which affects the

ability to perform transfers and use a manual wheelchair. At this stage, power wheelchairs often become necessary. The focus of care shifts towards maintaining comfort, preventing contractures, and managing scoliosis which can affect sitting posture and comfort.

In adulthood (ages 19 and older), progressive muscle weakness continues. Weakness in the respiratory muscles leads to difficulties with breathing and an increased risk of respiratory infections. Full-time use of a power wheelchair, careful monitoring for signs of respiratory distress, and management of cardiac complications are necessary. Lifestyle adjustments and assistive technologies are employed to maintain quality of life and independence in daily activities.

The progression and stages of DMD require a proactive approach in care to anticipate and manage the gradual increase in mobility challenges. This approach includes regular assessments by healthcare providers specializing in neuromuscular disorders, ongoing adaptation of care strategies, and support for both the physical and emotional well-being of the patient and their family.

Becker Muscular Dystrophy (BMD)

Becker Muscular Dystrophy (BMD) is a genetic muscle-wasting disease characterized by a slower progression compared to Duchenne Muscular Dystrophy (DMD). It results from mutations in the dystrophin gene that lead to the production of an altered, but partially functional, dystrophin protein. Progression and stages of mobility challenges vary per case, but are provided below.

The early stage (childhood to early adolescence) is when symptoms typically begin. The onset can vary widely, with some cases not manifesting until the late teen years or even early adulthood. Early signs often include muscle weakness in the pelvis and thighs, similar to DMD. The progression is slower, and symptoms might be less noticeable at first. Children may experience fatigue when walking,

difficulty in running, and a slight waddling gait. They might struggle with activities that require lower body strength, such as climbing stairs or rising from the floor.

The Intermediate stage (late adolescence to early adulthood) is marked by increasing muscle weakness. As individuals approach their late teens and twenties, muscle weakness progresses, but at a variable rate. The progression can extend over decades. Gait may become increasingly labored, and some individuals may begin using mobility aids such as canes or braces to help with walking and balance. To compensate for leg weakness, individuals might use the Gowers' maneuver, but less frequently than in DMD due to the slower progression of muscle weakness.

The advanced stage (mid to late adulthood) is marked by progression in many ways. The age at which an individual with BMD loses the ability to walk independently is highly variable. Many can walk well into their 30s or 40s, and some may retain walking ability much longer. Eventually, most individuals will require a wheelchair for mobility as leg muscles become too weak to support walking. The use of power wheelchairs may become necessary to maintain independence in mobility. Unlike DMD, individuals with BMD often maintain better upper body strength, which can help them manage daily activities and wheelchair mobility for a longer period.

The progression of Becker Muscular Dystrophy varies widely among individuals. Ongoing assessment by healthcare providers specializing in neuromuscular disorders is crucial to adapt care strategies over time, aiming to maximize functional abilities and quality of life.

Myotonic Muscular Dystrophy

Myotonic Muscular Dystrophy (MMD) is characterized by progressive muscle weakness and myotonia. Type 1 myotonic muscular dystrophy tends to have more

severe symptoms appearing earlier in life, and Type 2 (DM2) generally has milder symptoms appearing later. This section will overview the progression and mobility stages of myotonic muscular dystrophy.

Type 1 Myotonic Dystrophy (DM1)

With the early stage (childhood to early adulthood), symptoms begin in childhood, adolescence, or early adulthood. Early signs include facial weakness, drooping eyelids, and difficulty releasing grip (myotonia). Individuals may experience difficulty running, climbing stairs, or performing tasks that require fine motor skills. Mobility is preserved in early years, but fatigue and muscle weakness gradually become more prominent.

The middle stage (mid-adulthood) is marked by a progression of muscle weakness, particularly affecting the lower legs, hands, neck, and face. Grip strength diminishes due to myotonia and muscle wasting. Challenges with mobility increase, with some individuals beginning to use assistive devices such as canes or braces. Stairs and inclines become more difficult.

The advanced stage (late adulthood) is characterized by severe muscle weakness, as it becomes more pronounced and widespread, potentially affecting the ability to walk independently. Wheelchairs or scooters may be required for mobility as walking becomes increasingly difficult. Individuals may also face challenges with swallowing and speech due to muscle weakness.

Type 2 Myotonic Dystrophy (DM2)

With DM2, symptoms typically begin in the 30s or 40s but can be mild initially. Muscle pain and stiffness are common early symptoms, particularly in the thighs and hips. Myotonia is present but less severe than in DM1. Mobility issues are less pronounced at this stage, and many maintain a good level of activity. In the

advanced stage, which is later adulthood, muscle weakness tends to be slower and less severe than in DM1, but can eventually impact mobility. Some individuals may require aids for walking as muscle strength declines, especially in the legs. The use of assistive devices depends on the severity and specific muscle groups affected.

Facioscapulohumeral Muscular Dystrophy (FSHD)

Facioscapulohumeral Muscular Dystrophy (FSHD) is a genetic muscle disorder characterized by progressive skeletal muscle loss that initially affects the muscles of the face, shoulders, and upper arms, and later can affect the muscles around the pelvis and lower legs. Unlike some other forms of muscular dystrophy, FSHD typically has a slower and more variable progression.

In the early stage, symptoms can start in adolescence or early adulthood, but the timing of onset and progression can vary widely between individuals. The initial signs often include weakness in the facial muscles, which can lead to difficulties in smiling, whistling, or closing the eyes tightly. Weakness may also be noticeable in the shoulder girdle. Individuals might have difficulty lifting objects overhead, and there might be winging of the scapula due to weak shoulder stabilizers. In this early stage, most individuals retain full mobility, and the impact on daily activities might be minimal, focusing more on fine motor skills and facial expressions.

The intermediate stage is marked by muscle weakness that progresses to affect the upper arm and potentially the trunk. This can lead to further difficulties with activities that require arm strength and may affect posture. As the disease progresses, muscles around the pelvic girdle may begin to weaken. This can manifest as difficulty climbing stairs, rising from a seated position, or walking on uneven surfaces. Some individuals may start to use mobility aids for stability and safety, especially when muscle weakness begins to affect the legs.

The advanced stage is marked by muscle weakness that extends to the lower legs. This can impact balance and the ability to walk long distances. As lower limb involvement increases, the use of mobility aids such as canes, walkers, or wheelchairs may become necessary to maintain independence in mobility. Severe muscle weakness may require adaptations in the home and workplace to facilitate accessibility and ease of movement.

The variability in the progression of FSHD requires personalized treatment plans and proactive management to adapt to the changing abilities and needs of the individual. Although FSHD does not typically affect life expectancy, managing quality of life and maintaining independence are key goals in the treatment and support of individuals with this condition.

Limb-Girdle Muscular Dystrophy (LGMD)

Limb-Girdle Muscular Dystrophy (LGMD) is a group of genetically inherited disorders characterized by progressive muscle weakness primarily affecting the shoulder and pelvic girdles. There are numerous subtypes of LGMD, each associated with different genetic mutations and varying in age of onset, progression rate, and severity.

The early stage of LGMD and age of onset can vary widely, with some forms appearing in childhood and others not manifesting until adulthood. Early symptoms often include difficulty with tasks that require use of the shoulder or hip muscles, such as lifting objects, climbing stairs, or rising from a chair. Muscle weakness begins proximally, meaning it affects the muscles closest to the center of the body first. This includes the shoulders, upper arms, pelvic area, and thighs.

The intermediate stage is marked by progressive muscle weakness. It becomes more pronounced and may start to affect additional muscle groups. Individuals may start experiencing more significant challenges with mobility. Climbing stairs,

getting up from a sitting or lying position, and walking may become increasingly difficult. To maintain mobility and independence, individuals may begin using assistive devices such as canes or walkers. Modifications in the home, such as grab bars or stairlifts, might be necessary.

The advanced stage is marked by further muscle weakness, which may spread to other areas such as the arms, legs, and sometimes the neck. In some subtypes, respiratory muscles may also become affected. Many individuals with LGMD eventually require the use of a wheelchair as the disease progresses, especially as muscle strength in the legs continues to decline. Potential complications include contractures (permanent shortening of muscles or joints), scoliosis (curvature of the spine), and respiratory weakness. In some subtypes, there may be cardiac involvement, which requires monitoring and management.

Each subtype of LGMD may require specific management strategies based on the particular progression pattern and associated complications.

Body Systems Impacted ^{1,9,22}

As briefly mentioned previously, muscular dystrophy affects multiple body systems beyond just the skeletal muscles. The impact varies depending on the type of MD, but several systems are commonly involved across different forms. This section is meant to overview the different impact of MD on systems of the body.

Musculoskeletal System

The system which is impacted first and most harshly by MD is the musculoskeletal system. The hallmark of MD is progressive muscle weakness and degeneration, primarily affecting voluntary muscles. As muscles weaken and waste away, there can be tightening of the muscles and tendons (contractures), leading to joint deformities and reduced range of motion. Scoliosis is a common complication of

MD. So is osteoporosis, due to reduced mobility and chronic steroid use. These factors contribute to bone density loss, increasing fracture risk.

Cardiovascular System

Cardiomyopathy is common with some types of MD (especially Duchenne and Becker). These types can lead to weakening of the heart muscle, affecting its ability to pump blood effectively. Abnormal heart rhythms (arrhythmias) may develop due to changes in the cardiac muscle and its electrical properties. Progressive deterioration of heart function can lead to congestive heart failure.

Respiratory System

As MD progresses, the muscles that assist in breathing, such as the diaphragm and intercostal muscles, weaken. Reduced muscle strength can lead to inadequate ventilation, difficulty clearing secretions, and increased risk of respiratory infections. Advanced MD may require ventilatory support due to the inability of the respiratory muscles to sustain adequate breathing.

Gastrointestinal System

Dysphagia is caused by weakening of muscles involved in swallowing. It can lead to difficulty eating and drinking, increasing the risk of aspiration and malnutrition. Some individuals may experience problems with digestion due to slowed gastrointestinal motility, leading to constipation and other digestive issues.

Endocrine System

Delayed growth and development can occur, partly due to chronic illness, reduced physical activity, and the effects of long-term corticosteroid use. In addition, people with MD may develop glucose intolerance and diabetes. Corticosteroid use

and muscle deterioration can impact glucose metabolism, increasing the risk of type 2 diabetes.

Nervous System

Particularly in Duchenne muscular dystrophy, there can be mild cognitive impairment as the dystrophin protein is also expressed in the brain. In some forms of MD, there can be direct or indirect involvement of the peripheral nerves, leading to sensory or motor deficits (peripheral neuropathy).

As muscles weaken and waste away, changes in posture and muscle mass can lead to compression of peripheral nerves. For example, individuals with muscular dystrophy may develop foot drop if the peroneal nerve at the knee gets compressed, impacting the ability to lift the front part of the foot. In addition, some individuals with MD may experience neuropathic pain due to nerve dysfunction, which can occur when muscles and connective tissues that support nerves become progressively weakened or when nerves are compressed by contracted muscles or fibrotic tissue.

Immune System

The combined effects of immobility, respiratory dysfunction, and potential nutritional deficiencies can compromise the immune system, increasing susceptibility to infections, especially respiratory ones.

Urinary System

Urinary complications can occur due to reduced mobility and muscle weakness that leads to urinary retention, incomplete bladder emptying, and an increased risk of urinary tract infections. In some cases, MD can affect the nerves that control bladder function. This condition, known as neurogenic bladder, disrupts normal bladder signals, leading to problems with bladder storage and emptying.

Psychological Impact

Living with a chronic, progressively debilitating condition like MD can have significant psychological repercussions, including anxiety, depression, and social isolation. There is an increased prevalence of mood disorders such as depression and anxiety in individuals with MD. These conditions are often considered secondary to the stresses of living with a chronic, progressive disease but may also have a neurobiological component due to dystrophin deficiency in the brain.

Managing muscular dystrophy requires a multidisciplinary approach to address the wide range of body systems affected. This includes specialized care from cardiologists, pulmonologists, gastroenterologists, endocrinologists, neurologists, orthopedists, physical therapists, and mental health professionals. Effective management aims to slow disease progression, alleviate symptoms, and improve quality of life.

Section 2 Key Words

Autosomal Recessive Inheritance - A pattern of inheritance where both copies of a gene in an individual must have mutations for the recessive trait or disorder to be expressed

Creatine Kinase - An enzyme found primarily in the heart, brain, and skeletal muscles, which is particularly important because it plays a critical role in the energy metabolism of cells, especially muscle cells

Amyotrophic Lateral Sclerosis - Also known as Lou Gehrig's disease, is a progressive neurodegenerative disorder that affects motor neurons, the cells responsible for controlling voluntary muscle movement

Myasthenia Gravis - A chronic autoimmune disorder characterized by weakness and rapid fatigue of voluntary muscles

Charcot-Marie-Tooth Disease – A group of inherited disorders that affect the peripheral nerves

Section 2 Summary

Diagnosing MD requires examining many factors including genetic testing, clinical manifestations, and imaging. It is important to consider differential diagnoses of similar conditions to rule out similar conditions to find a path to treatment.

Factors such as expected progression of disease, stages of mobility challenges, and body systems affected are all crucial for physical therapists and assistants to be acutely aware of. These factors affect the approach of therapy, the plan of care, and expected outcomes working with individuals with MD.

PT Examination and Treatment

The role of physical therapy in the treatment of muscular dystrophy is to optimize function, improve mobility, and enhance overall quality of life for individuals affected by this condition. This section will overview orthopedic interventions that are integral to managing MD-related musculoskeletal complications, such as contractures and scoliosis, through strategies like stretching exercises, bracing, and orthopedic devices. It will discuss safety measures, including fall prevention strategies and adaptive equipment provision. In addition, it will go over plans of care, treatment and management of complications of the disease, and strategies of educating families of those impacted by MD.

Medical Management

Each type of MD varies in terms of onset, progression, and severity, necessitating tailored medical management strategies. This section overviews the medical

management of various types of muscular dystrophy, focusing on Duchenne, Becker, myotonic, facioscapulohumeral, and limb-girdle muscular dystrophies.

Duchene Muscular Dystrophy 5,30

DMD requires comprehensive medical management to slow the progression of the disease, alleviate symptoms, and improve quality of life. Besides physical and occupational therapy, these approaches include pharmacologic, cardiac, respiratory, orthopedic, and psychological support.

Pharmacologic Treatments

Corticosteroids, such as prednisone and deflazacort are the mainstays of treatment. These drugs help to slow muscle degeneration, improve muscle strength, delay the onset of some complications, and potentially extend ambulatory abilities and overall lifespan. Regular monitoring is required to manage side effects such as weight gain, bone fragility, and hypertension. Exon-skipping drugs like eteplirsen and golodirsen are designed for specific genetic mutations in DMD and can produce a shorter, functional form of dystrophin by skipping over faulty exons during mRNA processing. Research is ongoing in gene therapies that aim to introduce genetic material to produce a functional dystrophin protein or edit the dystrophin gene directly in muscle cells.

Cardiac Care

Routine monitoring such as regular echocardiograms are necessary to monitor heart function, as DMD often leads to cardiomyopathy. Cardiac medications like ACE inhibitors, beta-blockers, and aldosterone antagonists are commonly prescribed to manage cardiomyopathy and help maintain heart function.

Respiratory Management

Regular evaluations of lung function are crucial, especially as the disease progresses. Non-invasive ventilation (BiPAP) may be required at night initially and possibly full-time as respiratory muscles weaken. Cough assist devices that help to clear secretions are important to prevent respiratory infections.

Orthopedic Care

Monitoring for the development of scoliosis and other skeletal deformities is necessary. Surgical interventions may be required to manage scoliosis or correct contractures that significantly impact mobility or comfort. As muscle weakness progresses, scoliosis can become pronounced and may require surgical intervention to stabilize the spine and prevent further pulmonary complications. Achilles tendon release can be beneficial for those with tight heel cords to improve mobility and delay the progression to wheelchair dependence.

Psychosocial Support

Addressing the emotional and psychological needs of patients and their families through counseling and support groups is vital. This support helps manage the chronic stress and psychological impacts associated with long-term disease management. Educating patients, families, and caregivers about DMD progression and management strategies is crucial for empowering them to make informed decisions regarding care.

The management of Duchenne Muscular Dystrophy is multifaceted and evolving, with an emphasis on interdisciplinary care to address the wide range of clinical manifestations associated with the disease. Regular follow-ups with various specialists ensure that care remains comprehensive and responsive to the patient's changing needs.

Becker Muscular Dystrophy (BMD) 8,21

Management of BMD focuses on mitigating symptoms, preserving muscle function, and addressing complications as they arise. It is imperative that those with BMD receive pharmacological, cardiac, respiratory, and psychological management to live the highest quality of life possible.

Pharmacologic Treatments

While less commonly used in BMD than in DMD due to the slower progression and later onset of symptoms, corticosteroids like prednisone or deflazacort may still be prescribed to help maintain muscle strength and function. The decision to use steroids is often made on a case-by-case basis. Since cardiomyopathy is a common complication in BMD, medications such as ACE inhibitors, beta-blockers, and aldosterone antagonists are often used to help manage heart function and delay the progression of cardiac issues.

Cardiac Care

Regular cardiac evaluations, including echocardiograms and ECGs, are crucial due to the high risk of developing cardiomyopathy and arrhythmias. These tests help monitor heart health and guide treatment decisions. Early intervention with cardiac medications can help manage symptoms and prevent complications before they become severe.

Respiratory Care

Although respiratory complications are less severe in BMD than in DMD, it's important to monitor pulmonary function, especially as the disease progresses. Non-invasive ventilation may be required at night or later in the disease course to aid breathing and ensure adequate oxygenation.

Psychosocial Support

Counseling and support groups can be beneficial for dealing with the emotional and psychological challenges of living with a chronic condition. Education for family members about BMD and its management helps in providing support and in making informed decisions about care.

The management of Becker Muscular Dystrophy is comprehensive and multidisciplinary, requiring regular follow-ups with healthcare providers specialized in neuromuscular disorders. A proactive approach to treatment and regular monitoring of the progression can significantly improve quality of life and delay the onset of complications.

Myotonic Dystrophy 16,17

Myotonic Muscular Dystrophy (MMD), also known as Steinert's disease, is a type of muscular dystrophy characterized by muscle weakness, myotonia, and multisystem involvement. There are two main types, including Myotonic Dystrophy Type 1 (DM1) and Type 2 (DM2), with DM1 being more severe. Managing MMD requires a comprehensive approach that addresses both the neuromuscular and systemic aspects of the disease.

Pharmacologic Treatments

Pharmacologic treatment for MMD involves managing the various symptoms and complications associated with this multi-systemic disease. The primary goals are to improve muscle function, manage myotonia, and address the systemic issues that accompany MMD, such as cardiac abnormalities, endocrine problems, and other related conditions.

To manage myotonia, mexiletine may be prescribed. This is a medication primarily used to treat cardiac arrhythmias, but is also effective in reducing myotonia, helping to relieve muscle stiffness and improve muscle relaxation. Other

medications that can help manage myotonia include phenytoin, an antiepileptic drug that can also reduce myotonia, carbamazepine, another antiepileptic medication used to reduce muscle stiffness, and procainamide, which is less commonly used due to potential side effects but can be effective in some cases.

To manage the endocrine system, insulin or hypoglycemic agents may be prescribed. These are for patients who develop diabetes as a complication of MMD and management may include insulin therapy or oral hypoglycemic agents to control blood sugar levels. Levothyroxine also may be prescribed if thyroid function tests indicate hypothyroidism.

For the cardiac system, antiarrhythmics may be prescribed given the high risk of cardiac conduction defects in MMD. The choice of medication depends on the specific type of arrhythmia. Beta-blockers may be prescribed, which help manage arrhythmias and also mitigate some forms of cardiomyopathy. In addition, ACE Inhibitors may be used in patients with MMD to manage hypertension and help prevent the progression of heart disease.

While primarily supportive, bronchodilators and expectorants medications can help manage respiratory symptoms in patients with decreased pulmonary function.

Prokinetic agents are helpful for patients experiencing gastrointestinal motility issues. Medications like metoclopramide can help enhance gastric emptying. Laxatives and stool softeners are used to manage constipation, which can be a significant problem due to reduced physical mobility and certain medications.

Cardiac Care

Regular electrocardiograms (ECGs) are crucial for detecting changes in the electrical activity of the heart that may indicate arrhythmias or conduction block issues. For patients who exhibit symptoms or whose ECG suggests arrhythmia,

extended monitoring with a Holter monitor (a portable device worn continuously for 24-48 hours) can capture transient arrhythmic events or variations in heart rhythm. Echocardiography is an imaging technique used periodically to assess heart structure and function, looking for signs of cardiomyopathy or other structural cardiac abnormalities.

Respiratory Management

Pulmonary Function Tests are regular assessments using spirometry. These and other pulmonary function tests are crucial to monitor respiratory muscle strength and lung capacity. These tests help identify any decline in respiratory function, guiding the timing and nature of interventions. Overnight polysomnography can be used to detect sleep-disordered breathing, including sleep apnea, which is common in MMD due to muscle weakness affecting the upper airway. As respiratory muscles weaken, non-invasive ventilation such as BiPAP (Bilevel Positive Airway Pressure) or CPAP (Continuous Positive Airway Pressure) may be required, particularly at night. NIV helps maintain oxygen levels, reduce carbon dioxide buildup, and improve sleep quality. In advanced cases, some patients may require mechanical ventilation support during the day or full-time if their respiratory function significantly declines. For patients with chronic respiratory insufficiency and low oxygen saturation, supplemental oxygen may be necessary. Annual flu shots and pneumococcal vaccines are recommended to reduce the risk of respiratory infections. Early intervention with antibiotics for suspected bacterial infections can prevent complications like pneumonia.

Orthopedic Management

Orthopedic management is a crucial aspect of treating Myotonic Muscular Dystrophy (MMD), particularly because individuals with this condition often experience progressive muscle weakness and myotonia, which can lead to skeletal and joint abnormalities. Pain relief is targeted through short term pain

medications, like NSAIDs. Braces and other orthotic devices can be used to maintain joint alignment and mobility, and to prevent the progression of contractures, especially around the ankles and wrists. Regular spinal examinations and imaging studies are necessary to monitor for the development of scoliosis or other spinal deformities. In cases where scoliosis is mild, orthotic support such as a brace may be recommended to prevent further curvature. For severe scoliosis that impairs respiratory function or causes significant pain, surgical intervention, such as spinal fusion, might be necessary. Due to decreased mobility and potential steroid use, patients are at increased risk of osteoporosis. Regular bone density scans and appropriate supplementation with calcium and vitamin D are recommended.

Psychosocial Support

Psychosocial support is a critical component of treatment for those with MMD, as the condition not only affects physical health but also has significant emotional, psychological, and social impacts. Those with MMD may benefit from individual counseling. This can help individuals manage the emotional challenges associated with living with a chronic illness. Techniques like cognitive-behavioral therapy are particularly effective in addressing depressive symptoms, anxiety, and coping strategies. Support groups, disease education, and social integration are also helpful psychosocial support strategies.

As evident, managing MMD requires a comprehensive approach that addresses the neuromuscular and systemic aspects of the disease.

Facioscapulohumeral Muscular Dystrophy (FSHD) 13,19,31

There is currently no cure for FSHD, and medical management focuses on alleviating symptoms, maintaining function, and improving quality of life. This

section will focus on medical management of FSHD including pharmacologic, cardiac, respiratory, nutritional, orthopedic, and psychosocial strategies of care.

Pharmacologic Management

Currently, there is no specific pharmacological treatment that can halt or reverse the progression of Facioscapulohumeral Muscular Dystrophy. However, pharmacological approaches can be used to manage symptoms and complications associated with the disease.

NSAIDs are commonly prescribed for muscle pain and discomfort, which are frequent in individuals with FSHD. For more severe pain, other types of pain relievers, such as acetaminophen or even opioid medications, might be considered under careful medical supervision. Drugs such as gabapentin or pregabalin, often used for neuropathic pain, can sometimes be helpful in managing chronic pain conditions associated with muscular dystrophies. Corticosteroids are sometimes considered in cases where inflammation is a significant contributor to muscle pain or deterioration, under careful monitoring due to side effects. Muscle relaxants like Baclofen or Tizanidine can help relieve muscle spasms or stiffness, which some FSHD patients may experience.

Beta-blockers, ACE inhibitors, or angiotensin receptor blockers may be used if cardiac issues such as hypertension or early signs of heart dysfunction are present, as a preventative measure to protect heart health.

Cardiac Care

Individuals with FSHD should undergo regular cardiac evaluations to detect any early signs of cardiac involvement. This typically includes an electrocardiogram to assess the electrical activity of the heart and an echocardiogram to visualize heart function and structure. If an arrhythmia is detected, the specific type will guide the treatment approach, which could include medications like beta-blockers,

antiarrhythmic drugs, or use of devices like pacemakers or implantable cardioverter-defibrillators.

Respiratory Care

Although FSHD primarily affects the muscles of the face, shoulders, and upper arms, it can also lead to weakness in the muscles involved in breathing, such as the intercostal muscles and diaphragm, particularly in more advanced stages. Regular evaluations of lung function are recommended for individuals with FSHD, especially those who exhibit any signs of respiratory muscle weakness. Pulmonary function tests and sleep studies are important for this monitoring. Ventilation and cough assist devices may be used to help with respiration.

Orthopedic Management

Orthopedic management is essential in treating FSHD due to the progressive nature of the disease, which primarily affects skeletal muscles but can also lead to various orthopedic issues. Regular orthopedic evaluations should monitor for pain, function, and complications like scoliosis. Contracture management may be addressed as well through bracing, splinting, and stretching routines. Orthopedic management for FSHD requires a proactive and multidisciplinary approach, focusing on maintaining mobility and function, managing pain, and preventing complications.

Psychosocial Strategies

Individual therapy can help patients address feelings of anxiety, depression, and grief that often accompany a diagnosis of a chronic illness. Cognitive-behavioral therapy is particularly effective in helping individuals develop coping strategies to manage stress and adapt to lifestyle changes. Family therapy, support groups, and regular social activities can help those with FSHD.

While the management of FSHD is primarily supportive and aimed at symptom control, an integrated approach involving various specialties can help maximize function and enhance quality of life. Advances in research may also provide new opportunities for more targeted therapies in the future.

Limb-Girdle Muscular Dystrophy (LGMD) 10,32

Limb-Girdle Muscular Dystrophy encompasses a diverse group of genetic disorders characterized by progressive weakness and wasting of the muscles primarily around the hips and shoulders. Due to the heterogeneity of LGMD, which includes many subtypes each associated with different genetic mutations, the medical management strategies can vary significantly, but general concepts apply.

Pharmacologic Management

Although not as commonly used in LGMD as in Duchenne Muscular Dystrophy, corticosteroids such as prednisone may sometimes be prescribed to manage inflammation and help maintain muscle strength and function in certain subtypes of LGMD. For LGMD subtypes with cardiac involvement, various medications may be used to manage heart function, such as ACE inhibitors, beta-blockers, and antiarrhythmics. NSAIDs and anticonvulsants may be prescribed for pain.

Bronchodilators can be prescribed for increased respiration. Bisphosphonates, vitamin D and calcium supplements may be prescribed for patients on long-term corticosteroid therapy or those with reduced mobility. Medications to strengthen bones and prevent osteoporosis may be recommended.

Cardiac Care

Proper cardiac management can significantly impact the prognosis and quality of life for individuals with LGMD. Routine ECG, echocardiogram, and Holter monitoring are important for detecting electrical abnormalities, heart function,

and arrhythmias. Medication and patient education on lifestyle modification are key treatments for cardiac problems associated with LGMD.

Respiratory Care

Effective management of respiratory function is essential to prevent complications such as pneumonia and respiratory failure, which are significant risks as the disease progresses. Regular pulmonary function tests and sleep studies will help to assess and improve lung function with LGMD. In addition, infection prevention, ventilation, and cough assist techniques may be helpful in management of respiratory complications.

Orthopedic Management

Orthotic devices like braces can support weakened muscles, improve posture, and aid in walking or standing. Ankle-foot orthoses, knee braces, and spinal braces are commonly used. Surgery may be required to correct severe joint deformities or scoliosis, which is common in individuals with LGMD. Orthopedic surgeons will carefully assess the risks and benefits of surgery based on the individual's health status and disease progression. Regular check-ups with an orthopedic specialist are important to monitor the progression of muscle weakness and skeletal changes, and to adjust treatments as necessary.

Psychosocial Strategies

Individual therapy can assist patients in dealing with feelings of anxiety, depression, and grief that frequently arise following a diagnosis of a chronic illness. Cognitive-behavioral therapy is especially beneficial in helping individuals devise coping strategies to handle stress and adjust to new lifestyle changes. Additionally, family therapy, support groups, and consistent social engagement can support individuals with LGMD.

The management of LGMD is primarily supportive and a multidisciplinary approach involving various specialties can help maximize function and enhance quality of life.

Physical Therapy Examination and Evaluation ^{9,21,30}

In order to effectively intervene with a physical therapy plan of care for patients with MD, physical therapists should conduct a thorough examination on several outcomes. This section will overview patient history, physical examination, neurological assessment, special tests, a pain assessment, a psychosocial assessment, and an assessment for assistive devices.

Patient History

A detailed patient history is meant to gather information about the onset, progression, and current status of the disease. Physical therapists should inquire about and/or gain medical records of detailed genetic and neuromuscular history, including specifics about genetic testing results, type of MD, and onset of symptoms. They should have a clear history of medical, surgical, and physical therapy interventions, including efficacy and outcomes. In addition, they should know current functional status and changes to that. Quantitative measures of changes over time, based on standardized functional outcome scales like the Brooke Scale for upper extremity and the Vignos Scale for lower extremity function.

Brooke Score

Brooke Score	Description
1	Starting with arms at the sides, the patient can abduct the arms in a full circle until they touch
2	Can raise arms above head only by flexing the elbow (shortening the circumference of the movement) or using accessory muscles
3	Cannot raise hands above head, but can raise a 8-oz glass of water to the mouth
4	Can raise hands to the mouth, but cannot raise a 8-oz glass of water to the mouth
5	Cannot raise hands to the mouth, but can use hands to hold a pen or pick up pennies from the table
6	Cannot raise hands to the mouth and has no useful function of the hands

https://www.researchgate.net/figure/Description-of-the-Brooke-scores-Table-reproduced-from-18_tbl1_314078805

Vignos Scale

1. Walks and climbs stairs without assistance
2. Walks and climbs stairs with aid of railing
3. Walks and climbs stairs slowly with aid of railing (over 12 seconds for 4 standard stairs)
4. Walks unassisted and rises from chair but cannot climb stairs.
5. Walks unassisted but cannot rise from chair or climb stairs.
6. Walks only with assistance.
7. Participant is dependent on wheelchair for all mobility.
8. Participant is in bed at all times.

https://www.researchgate.net/figure/Vignos-lower-extremity-scale_fig1_352526331

Physical Examination

The goal of the physical examination is to evaluate the physical manifestations of MD and assess muscular function and joint integrity.

Muscle Strength Testing. Therapists may utilize manual muscle testing or dynamometers to evaluate the strength of various muscle groups – especially those that appear weak on functional movement assessment or gait analysis.

Range of Motion (ROM) Assessment. Therapists should conduct a range of motion assessment, actively and passively on any affected joints.

Functional Mobility Testing. A functional mobility assessment is tailored to the patient based on their mobility challenges. It should include any of the following that are possible: ambulation, sit to stand, standing, stair negotiation, and sitting unsupported. Therapists should record the ability of patients to do each of these tasks and how much assistance is required. Implementation of standardized tests such as the 6-Minute Walk Test (6MWT) to evaluate endurance and functional mobility.

Neurological Examination

Therapists need to assess muscle strength and muscle tone to determine whether there are signs of hypertonicity or hypotonicity. In addition, deep tendon reflexes should be assessed. They may be reduced or absent in MD, especially in the late stages. Gait analysis should be performed to identify gait abnormalities typical of MD, such as waddling or toe walking.

Common gait abnormalities with MD include waddling gait, toe walking, Trendelenburg gait, and steppage gait. Waddling gait pattern is typical in many forms of MD, especially Duchenne Muscular Dystrophy (DMD) and Becker Muscular Dystrophy. It involves a distinctive side-to-side motion due to weakness in the hip and pelvic muscles. Individuals often shift their body weight from side to side to compensate for the lack of stability and strength in these areas. Toe walking is frequently seen in the early stages of DMD and occurs because of calf muscle tightness or contractures. Individuals walk on their toes or the balls of

their feet as it becomes difficult to place their heels on the ground. Trendelenburg gait is characterized by a dropping of the hip on the side opposite to the lifted leg during walking, due to contralateral gluteal weakness. Steppage gait is less common in MD and more typical of neuropathic conditions but occurs when leg muscles become severely weakened. The person raises their thighs excessively as in climbing stairs, because the feet and toes point downwards during the swing phase, making it difficult to clear the ground.

Sensory testing, including pain, temperature, vibration, light touch, and proprioception should be tested. These are typically left intact with MD but are part of a comprehensive neurological examination. A finger-to-nose test should be performed to assess cerebellar function by asking the patient to touch their nose with their fingertip, then reach out to touch the examiner's finger. In addition, the heel-shin test will evaluate lower limb coordination by having the patient slide their heel up and down the opposite shin. Static and dynamic balance should be performed, using tests like the Berg Balance Scale or Timed Up and Go (TUG) test. Cranial nerve testing, facial symmetry and strength, and eye movements are also part of a comprehensive neurological examination. Cognitive screening for memory, executive function, and attention should be performed if indicated.

Pain Assessment

Physical therapists should evaluate any pain that may be affecting mobility and quality of life. This may include pain scales, such as using tools like the Visual Analog Scale (VAS) or the Numeric Pain Rating Scale (NPRS) to quantify pain levels. Identifying characteristics of the pain such as location, frequency, and triggers is crucial to document as the condition progresses.

Psychosocial Assessment

Physical therapists should understand the emotional and social aspects affecting the patient due to MD. They should assess the impact of MD on mental health, including signs of depression or anxiety. They may use scales such as the Patient Health Questionnaire 2 or 9 to screen for depression and the Generalized Anxiety Disorder scale (GAD 7) to screen for anxiety. If patients score in the moderate to high numbers in these measures, they should be referred to a mental health professional. In addition, understanding the patient's social interactions and any barriers they face is helpful in providing patient-centered care.

Equipment and Assistive Device Evaluation

Physical therapists should determine the need for and proper use of any assistive devices and other adaptive equipment. They should evaluate the effectiveness and appropriateness of currently used devices such as braces, walkers, or wheelchairs with a functional evaluation. In the early stages, canes and walkers are used for balance and stability. In intermediate to advanced stages, manual and power wheelchairs are used to optimize safety and mobility. Orthotic devices, such as ankle-foot orthoses (AFOs) may be used for patients to ambulate safely. Bathroom equipment like shower chairs, grab bars, and raised toilet seats may be utilized for safety.

It is imperative to comprehensively evaluate the mobility challenges, strength, range of motion, and other aspects of the clinical picture for patients with MD. Progress or regression should be noted periodically in reevaluations and progress notes.

Physical Therapy Management - Orthopedics ³³

Physical therapy management for muscular dystrophy aims to slow the progression of muscle weakness, prevent complications such as contractures and respiratory distress, and improve the overall quality of life. This is achieved through various therapeutic strategies including a range of motion exercises, strengthening programs, aerobic conditioning, and the use of adaptive equipment. Regular assessment by a physical therapist is critical, as the therapy needs may evolve as the disease progresses. In addition to direct interventions, physical therapists should also provide guidance on lifestyle modifications and adaptive techniques to help individuals navigate daily activities. The goal is to empower patients with muscular dystrophy to maintain an active and fulfilling life within the limitations of their condition.

Aerobic and Strengthening Exercises ^{20,34,35}

It is crucial to understand the underlying pathophysiological changes in muscle tissue and tailor interventions to address specific deficits associated with different stages of the disease. Muscular dystrophy leads to a continuous decline in muscle mass and strength, prompting concerns that exercise could be detrimental by causing muscle damage, inflammation, and impaired muscle repair, potentially leading to worsened conditions, such as overwork weakness from extremely intense, high-impact activities. Conversely, avoiding physical activity can result in a decrease in functional abilities, increased weight gain, heightened fatigue, and could potentially intensify and hasten the progression of muscular dystrophy symptoms. Research indicates that muscular exercise has led to slight enhancements in walking endurance for individuals with muscular dystrophy, though it is not advisable for boosting strength, managing motor skills, or reducing fatigue. Furthermore, studies have shown that eccentric exercises and high-load resistance activities tend to exacerbate muscle breakdown. In contrast, isometric

exercises or body weight resistance activities, when properly scaled to prevent excessive fatigue, are more advantageous. It is imperative throughout activation and strengthening exercises that physical therapy focuses on finding a balance between optimizing and preserving function while not contributing to irreversible muscle degradation.

Early Stages of MD

During the early stages of MD, muscle strength is relatively better preserved, but the initiation of muscle degeneration has begun. The goal of exercises is to delay the progression of muscle atrophy and maintain neuromuscular function.

Research is inconclusive on the utility of strengthening exercises for those with MD. Some studies suggest in the early stages of disease progression, dependent on the type, that implementing controlled, isotonic exercises focusing on slow-twitch muscle fibers is helpful. The reasoning for this is because these fibers are less susceptible to damage. Therapists should utilize equipment that allows for adjustable resistance levels, such as electronic resistance machines, to precisely target and monitor workload. The load should be light with a rating of perceived exertion (RPE) of 1-3/10. Patients should perform one to three sets of six to fifteen repetitions for target activation and strengthening. Target muscles should include major muscle groups used functionally for walking and transfers, such as quadriceps, glutes, core, and the shoulder girdle. Target muscles will vary per type of MD, however. Those with FSHD may tolerate trunk and lower extremity exercises at higher resistances, and those with DMD tolerate trunk strength training exercises best. Strengthening exercises in early stages of MD can improve endurance, upper limb function, balance, gait pattern, and measures of well-being.

Aerobic training programs may be utilized to maintain cardiovascular health and functional capacity. Exercises like swimming, walking, or stationary cycling should

be performed at a light intensity. Intensity can be calculated by RPE and oxygen saturation. Studies suggest that alone, strength or aerobic training, does not improve functional outcomes much. However, strength and aerobic training combined did produce statistically significant improvements in functional outcomes.

The following is a suggested early stage aerobic and strength exercise program for a patient with an early stage of MD.

Aerobic Component

Swimming or Aquatic Therapy. Water provides buoyancy that reduces stress on muscles and joints, making it ideal for those with progressive muscle weakness. Therapists should instruct patients to aim for 20-30 minutes of gentle swimming or water aerobics sessions, 2-3 times per week.

Stationary Cycling. A stationary bike, especially a recumbent bike, allows for cardiovascular exercise that is low-impact for joints and appropriate intensity for muscles. Patients with MD should start with 10-15 minutes of gentle cycling, gradually increasing the duration as tolerated but not the intensity of resistance, aiming for sessions of 20-30 minutes, 3-4 times per week.

Walking. If possible, patients in early stages of MD should incorporate walking at a comfortable pace. They should be instructed by PT to begin with short walks of 10-15 minutes, and gradually increase as tolerated, aiming for longer walks up to 30 minutes, 3-4 times per week. Of course, safety with ambulation should be assessed before recommending this outside of the PT clinic.

Strengthening Component

Strength training in the early stages of muscular dystrophy should focus on maintaining muscle mass and preventing atrophy. Using low resistance and high repetitions to avoid overworking the muscles is critical.

Resistance Bands. PT should start by utilizing light resistance bands to perform lower extremity and upper extremity exercises like band pulls, leg presses, or arm curls. Parameters should be 2-3 sets of 10 to 15 repetitions for each exercise, focusing on major muscle groups. Sessions can be 2-3 times per week. Resistance should be light, and RPE should be 1-4/10.

Free Weights or Stationary Machines. Using very light weights, physical therapy may include basic exercises such as bicep curls, shoulder presses, rows, squats, and wrist curls. As with resistance bands, aim for 2-3 sets of 10-15 repetitions, adjusting as necessary based on muscle fatigue. There should be an RPE of no greater than 4/10.

Intermediate Stage of MD

For individuals with muscular dystrophy (MD) in the intermediate stages, the focus of physical therapy shifts towards maintaining as much independence and mobility as possible, while managing the increasing muscle weakness.

Aerobic Component

For individuals in the intermediate stage of muscular dystrophy (MD), maintaining cardiovascular fitness remains essential, although exercises must be carefully selected to accommodate increased muscle weakness while minimizing risk. Aerobic exercises should focus on low-impact activities that maintain heart health and endurance without overburdening weakened muscles. It's crucial to monitor for signs of fatigue or muscle weakness during exercise. Individuals should stop the activity if they feel overly fatigued, dizzy, or if there is notable muscle weakness. Patients should be educated to ensure proper hydration before, during, and after exercise. Additionally, adequate rest periods should be incorporated to prevent overexertion. It is crucial that PTs and patients with MD are prepared to

adapt exercise routines based on daily physical status and progressive symptoms. Flexibility in planning allows for adjustments based on better and worse days.

Examples of appropriate aerobic exercises for the intermediate stages of MD include the following.

Recumbent Cycling. A recumbent bike offers a comfortable seating position that reduces stress on the back and lower limbs, making it ideal for those with muscle weakness and any musculoskeletal complications like scoliosis. Physical therapists should instruct patients in beginning with short sessions of about 10-15 minutes, 3 times a week, and adjust duration based on individual tolerance and response. Patients should maintain a light to moderate pace that allows for conversation without leading to breathlessness, or an RPE of 1-3/10.

Aquatic Therapy. Water provides natural resistance and buoyancy, significantly reducing the strain on muscles and joints while still allowing for effective cardiovascular training. It is optimal to work up to sessions of 20-30 minutes, 2-3 times per week. Physical therapists should be trained in providing aquatic therapy safely, especially because significant mobility challenges arise in the intermediate phases of MD. Aquatic therapy will involve gentle movements such as walking, leg lifts, and arm strokes in water; use aqua noodles or boards for added support and resistance.

Arm Ergometry. An upper body ergometer works the cardiovascular system and helps maintain upper body strength without stressing the legs, which is useful in DMD, LGMD, and other forms of MD that affect the lower extremities. Therapists should have patients start with 5-10 minute sessions, gradually increasing as tolerated, ideally 2-3 times per week. Intensity should be at a comfortable resistance setting that allows for sustained activity without excessive fatigue, or an RPE of 1-3/10.

Gentle Walking. If walking is still feasible, gentle, short walks can be beneficial. Using a treadmill with handrails for support can help manage balance and ensure safety. Physical therapists should guard appropriately against losses of balance throughout this stage. Overground ambulation with a gait belt and an assistive device if needed is also an option. Short walks of 10-15 minutes, gradually extending the duration as tolerated, up to 30 minutes, 3-4 times per week is recommended. People with MD should walk at a pace that does not cause undue fatigue or muscle weakness, adjusting speed to ensure it remains manageable.

Strengthening Component

Strengthening exercises in the intermediate phases of MD should focus on the maintenance of current strength and functionality, not pursuing strength improvements. This stage is critical for those with MD to work under the guidance of a physical therapist. Regular training with adaptability is crucial during this phase. Those with intermediate MD should engage in strength training activities 2-3 times a week, ensuring there is at least one day of rest between sessions to allow muscles to recover. The intensity should be low to avoid muscle strain. Here are examples of exercises that may be performed in the intermediate phase of MD.

Isometric Exercises. These exercises involve muscle contractions without joint movements. They can help maintain muscle strength without straining muscles. An example is a chair squeeze, where one would place a ball between the knees, and squeeze the knees together.

Light Resistance Training. Using low resistance with elastic bands, light weights, or machines can help maintain muscle strength. An example is seated rows with a light resistance band and leg curls with light resistance around the foot. The recumbent leg press could be used to push gently against light resistance. One

should perform about 12-15 repetitions of these exercises, where they feel an RPE of less than 3/10.

Pool Exercises. In addition to the aerobic benefit of aquatic therapy, it has an enormous benefit on maintaining strength. An example is walking in waist-deep water from one side of the pool to the other. Another example is water aerobics, which uses water weights or noodles for resistance while performing arm curls and leg kicks.

Functional Exercises. These exercises focus on movements that are part of everyday activities, helping maintain independence. Depending on mobility safety and functionality of a person in the intermediate stages of MD, functional exercises are key to maintain strength safely. A sit to stand is a basic functional exercise that targets the quadriceps, gluteals, and core. It should be dosed to 12-15 repetitions and a light RPE (less than 3/10 on RPE scale). Step ups are another functional exercise to maintain strength. PTs should guide patients to use a low step, step up with one foot followed by the other, then step down in reverse order, guarding for safety with a gait belt.

Advanced Stage of MD

For individuals with advanced stage muscular dystrophy (MD), exercise and physical activity should focus primarily on maintaining comfort, preventing complications, and preserving as much independence as possible. The severity of muscle weakness at this stage often limits the type and intensity of exercise that can be safely performed.

Aerobic Component

Aerobic exercise in advanced MD is typically very mild and focuses on promoting cardiovascular health without causing fatigue. It should only be performed if it adds quality of life to the patient. All exercises should prioritize patient comfort

and avoid any form of strain or pain. Examples of aerobic exercise possibilities are below.

Seated or Reclined Exercises Description. Patients may participate in arm cycling or gentle chair aerobics, such as arm movements and leg marches. In a group inpatient setting, there is the benefit of exercising socially to improve quality of life.

Aquatic Therapy. Water therapy can be beneficial due to the buoyancy that reduces musculoskeletal pain. Examples are gentle floating and leg movement. Supported floating with gentle leg kicks, assisted by a therapist or flotation device can help maintain muscle strength.

Strengthening Component

At this stage, maintaining muscle tone and flexibility becomes the priority, often using very gentle, passive or assisted exercises. The following are examples of appropriate strengthening exercises for those with MD.

Passive and assisted range exercises. These exercises are performed by a therapist who moves the patient's limbs to help maintain joint mobility and reduce stiffness without requiring muscle exertion by the patient. Arm and leg lifts into flexion, abduction, and other directions should be targeted by gently lifting and moving the arms and legs through their full range of motion. The patient should be instructed to try to move their limb with the passive movement to make it actively assisted.

Isometric Exercises. If possible, given the extent of weakness, isometric exercises can help maintain some muscle strength without movement of the joints. An example is a gluteal squeeze, where the patient would contract their gluteals and hold the contraction for a few seconds.

Both aerobic and strengthening exercises have their place in a physical therapy program to maintain function and quality of life for those with Muscular Dystrophy. All interventions should be selected based on individual patient factors and examination.

Stretching and Range of Motion ^{33,36}

For individuals with muscular dystrophy (MD), a structured flexibility and stretching program is a critical component of physical therapy intervention to maintain joint range of motion, decrease the risk of contractures, enhance circulation, reduce the risk of joint deformities, and enhance overall functional mobility. Here's a detailed and technical breakdown of how to implement these interventions:

Types of Stretching Interventions

Passive Static Stretching. With passive stretching, the therapist or caregiver manually stretches the muscle without any effort from the patient (or from the target muscle group), moving the joint through its full range of motion.. There should be mild tension within the muscle felt by the patient, but not to the point of pain or discomfort. This should be held for 30 seconds, repeated 2-3 times per session, and performed 3-4 times daily.

Active-Assisted Stretching. The patient actively participates in the stretching with some assistance from the therapist to achieve a fuller range of motion. This is ideal for patients who can initiate movement but cannot fully complete the stretch due to strength limitations.

Stretching programs should focus on muscle groups most at risk for contractures and stiffness, such as hip flexors, hamstrings, quadriceps, and gastrocnemius, biceps, triceps, wrist flexors, shoulder adductors, and spinal muscles particularly if scoliosis is present or developing.

Types of Range of Motion Interventions

Range of motion exercises play a critical role in the management of muscular dystrophy (MD), aiming to maintain or improve joint flexibility, prevent the development of contractures, and enhance overall mobility. Therapists should target joints based on the examination and progress visit results.

Passive Range of Motion (PROM). PROM exercises involve a caregiver or therapist moving the patient's limbs through their full range of motion without any effort from the patient. PROM is crucial especially when the patient cannot perform the movement due to muscle weakness. These may be used for all major joints including shoulders, elbows, wrists, hips, knees, and ankles.

Active-Assisted Range of Motion (AAROM). The patient performs the movement with some assistance from a therapist or caregiver. This is used when the patient can initiate movement but cannot complete the range due to weakness or fatigue. These are typically used in transitioning phases where the patient still retains some muscular strength and control.

Active Range of Motion (AROM). The patient independently performs the exercise using their own muscle strength to move the joints through their range. These are ideal for early stages of MD or when significant muscle function is still present.

All ROM exercises are most beneficial when performed daily. For severe cases, multiple sessions per day may be recommended to effectively maintain joint flexibility. Each joint should be moved through its full range gradually and gently. Movements should be repeated 10-15 times per session, depending on the individual's tolerance. Sessions per day should be around 2-4, depending on the severity of joint mobility restriction (more restriction should have more sessions).

By maintaining a structured and regularly assessed stretching program, physical therapists can significantly contribute to managing the symptoms of muscular dystrophy, preserving mobility, and improving the quality of life for these patients.

Activity Modification ^{23,34}

Activity modification in physical therapy for individuals with muscular dystrophy (MD) is essential to optimize function, maximize independence, and prevent complications. Recommendations for activity modification need to be personalized, reflecting the type and severity of MD, as well as the individual's current physical capabilities and goals and some are suggested below.

Energy Conservation Techniques. The goal of energy conservation techniques are to manage fatigue by balancing activity with rest, ensuring that patients maintain activity without overexertion. Therapists should encourage planning daily activities with scheduled rest periods in between to avoid fatigue. They should help patients prioritize activities to focus on essential tasks when their energy levels are highest, typically earlier in the day. In addition, it is useful to recommend tools like a reacher to pick up items, or a shower chair to conserve energy during personal care.

Work and School Modifications. The goal is to ensure a supportive environment that accommodates the individual's physical limitations. PTs should suggest ergonomic workplace or school adaptations, such as adjustable desks or chairs that support posture and ease transitions between sitting and standing. In addition, they should advocate for flexible hours or breaks to manage fatigue and physical strain. Also, they should ensure that the environment is wheelchair accessible, including ramps, elevators, and accessible restrooms.

Home Modifications. The objective is to create a safe and accessible living space that promotes independence and prevents falls. PTs should advise on rearranging

furniture to create clear pathways for easier mobility. If necessary for safety, they should recommend installation of grab bars, non-slip mats, and raised toilet seats to enhance safety in the bathroom. In addition, they should suggest modifications like lower countertop heights and the use of sliding shelves to facilitate accessibility and reduce the need to stretch or bend.

Recreational Activities. PTs should encourage participation in social and recreational activities that are feasible given the patient's physical capabilities. Introducing sports like adaptive cycling, wheelchair basketball, or swimming are less demanding on muscles but provide cardiovascular benefits and social interaction. Encouraging joining support groups or community activities that can be adapted for those with limited mobility can help patients feel like they have a community.

Exercise Modifications. The goals of exercise programs in patients with MD is to maintain muscle function and cardiovascular health without causing muscle damage. This is achieved by low-impact exercises, and low-fatigue exercises such as swimming or stationary cycling that do not overburden the muscles. It is crucial that physical therapists guide patients with MD or that they enter programs specifically designed for individuals with neuromuscular conditions, monitored by other healthcare professionals.

Safety and Activities of Daily Living ^{6,33}

When designing a physical therapy intervention focusing on safety and activities of daily living (ADLs) for individuals with muscular dystrophy (MD), therapists must consider the progressive nature of the disease and the varying degrees of muscle weakness that patients experience.

The first step to implementing safety and ADL training is a comprehensive evaluation focusing on functional mobility required for ADLs. Initial and ongoing

assessments should evaluate muscle strength, joint flexibility, balance, coordination, and overall mobility. This helps in identifying specific challenges the individual faces with daily activities.

Risk Assessment for Falls. As muscle weakness progresses, the risk of falls increases. Assessing the home environment for fall hazards (such as loose rugs, inadequate lighting, and lack of handrails) is crucial.

Mobility Training

Gait training is imperative in a plan of care for muscular dystrophy physical therapy. The therapist should educate the patient by using tactile or verbal cues for safe walking techniques, incorporating the use of assistive devices like canes or walkers.

For individuals with significant mobility restrictions, training in the use of a manual or power wheelchair is essential. This includes navigating different terrains, turning, and transferring.

Balance and Coordination Training

Stability exercises improve core strength and balance, such as sitting and standing balance exercises, can help stabilize movements and reduce the risk of falls. These are essential in a plan of care for MD and should simulate required tasks and goals of the patient.

Safety Enhancements in the Home

Physical therapists should suggest installation of grab bars in the bathroom, ramps for entryways instead of stairs, and stairlifts if necessary. Furniture should be organized to create clear pathways for easier navigation around the house.

Training for ADLs

The therapist should provide mobility training that translates to techniques to aid in dressing, grooming, and hygiene that accommodate reduced muscle strength. This includes energy conservation, suggesting position changes (sitting versus standing), and accommodating for balance and contractures.

Equipment Selection 6,34

For patients with muscular dystrophy (MD), a variety of assistive devices and equipment are available to support daily living, mobility, and overall functionality. These devices are tailored to individual needs based on the progression and specific symptoms of the disease.

Mobility Aids

When considering different mobility aids and assistive devices, it is crucial to maximize independence while optimizing safety. Physical therapists should assess and reassess patients ambulating with different mobility aids to ensure they have chosen the least restrictive assistive device that promotes the safest and most efficient mobility.

Canes. Canes provide balance support for those with mild lower limb weakness. Choices are a single point or a four point cane. The four point cane offers more stability but is sometimes bulky and difficult to negotiate.

Walkers. Walkers offer more stability than canes, and therapists may consider a standard (walker with no wheels), a front wheeled walker, or a rollator walker (equipped with wheels, brakes and a seat).

Manual Wheelchairs. These allow greater mobility for individuals with moderate to severe muscle weakness. They require sufficient upper body strength or assistance from caregivers.

Powered Wheelchairs. These are ideal for individuals with severe muscle weakness, providing independence without physical strain. They may at first be used for community mobility, and eventually for household mobility when walking is not feasible.

Scooters. Scooters are useful for outdoor use or in large indoor spaces, providing mobility for those with limited walking ability.

Orthotic Devices

Orthotic devices play a crucial role in managing muscular dystrophy (MD) by providing support, stabilizing weak muscles, preventing contractures, and enhancing mobility. These devices are tailored to individual needs, depending on the type and progression of MD, and are often an integral part of a comprehensive treatment plan.

Ankle-Foot Orthoses (AFOs). These devices help manage foot drop and provide stability during walking by preventing foot drop and allowing clearance of the foot during the swing phase of gait.

Knee-Ankle-Foot Orthoses (KAFOs). These stabilize both the knee and ankle for those who require additional support.

Wrist Hand Orthoses (WHO). These support the wrist and hand, helping to maintain hand function and alignment.

Spinal Orthoses. Spinal orthoses are prescribed for MD patients who develop scoliosis or other spinal deformities due to muscle imbalances. These deformities can compromise respiratory function and cause pain.

Adaptive Equipment for Daily Living

Adaptive equipment for daily living is essential for individuals with muscular dystrophy (MD) to maintain independence, manage routine activities with less assistance, and enhance overall quality of life. This equipment is typically managed by occupational therapy and includes the following.

Reaching tools are long-handled grabbers that help individuals reach and pick up objects without bending.

Adaptive utensils are eating utensils with modified handles for easier grip and use, beneficial for those with reduced hand strength.

Dressing aides include devices like button hooks, zipper pulls, and elastic shoe laces to facilitate dressing independently.

Shower chairs or benches provide a safe, seated option for showering.

Grab bars are installed in showers and around toilets to aid in transfers and prevent falls.

Raised toilet seats help reduce the distance when sitting down or standing up from the toilet.

Home Modifications

Home modifications can range from simple changes to more comprehensive renovations, all aimed at accommodating mobility limitations and enhancing the quality of life of patients with MD. Ramps replace stairs to allow wheelchair access into and within the home. Stair lifts are mechanical devices that transport individuals up and down stairs without needing to leave their wheelchair or seat. Door widening accommodates wheelchairs and makes navigation easier through

doorways. Automatic door openers enable doors to be opened and closed using a remote or button, reducing physical exertion.

Family Education ^{33,36}

Education for families of individuals with muscular dystrophy is an integral part of the treatment plan. Physical therapists play a crucial role in providing this education, helping families understand the condition, the progression of symptoms, and how to best support their loved one's mobility and daily activities. Topics of education are below.

Disease Process and Progression. Physical therapists should explain the genetic nature of MD, the types of muscles affected, and the typical progression of muscle weakness. Understanding the specifics of the type of MD their loved one has (Duchenne, Becker, etc.) can help tailor care and expectations.

Symptom Management. PTs should discuss common symptoms such as muscle weakness, fatigue, and potential complications like contractures and respiratory issues.

Activity Planning. PTs should educate families on how to plan activities that accommodate the energy levels of the person with MD, emphasizing the importance of regular rest periods to prevent fatigue.

Exercise and Physical Activity. It is imperative to guide families on appropriate exercises, including stretching, strengthening, and aerobic exercises that are safe for individuals with MD to help maintain function and reduce complications.

Use of Mobility Aids. PTs should teach families about different types of mobility aids such as canes, walkers, wheelchairs, and when each might be appropriate as the disease progresses. They should also be aware of adjustment of orthotics, wheelchairs, and other devices to ensure they are functioning correctly and safely.

Home Modifications. Families should be advised on modifications to make the home safer and more accessible, such as installing grab bars, ramps, and widening doorways.

Fall Prevention. PTs should also discuss strategies to minimize the risk of falls by organizing the living space, using non-slip mats, and ensuring adequate lighting.

Coping Mechanisms. PTs should address the emotional impact of MD on both the patient and family, suggesting ways to cope with the challenges of the disease. They should encourage connection with support groups or online communities for MD families to share experiences and advice.

Techniques for Assisting. PTs should train caregivers in safe techniques for transferring, lifting, or assisting with mobility to prevent injury to both the caregiver and the individual with MD.

Respite Care. PTs should inform about the importance of respite care for caregivers to manage stress and maintain their own health.

Advance Planning. PTs should discuss the importance of planning for future needs, including potential changes in care requirements and making legal and healthcare decisions.

Emergency Situations. In home care, PTs may educate families on what to do in an emergency, how to explain their loved one's condition to emergency responders, and what medical information to have readily available.

Prevention of Secondary Complications ^{6,34}

Physical therapists play a crucial role in managing muscular dystrophy (MD) and are key to preventing secondary complications that can arise from the disease. Here are several strategies physical therapists employ to prevent secondary

complications in individuals with MD, besides maintaining mobility, promoting aerobic fitness, and preventing contractures.

Improving Respiratory Function

Breathing Exercises. Physical therapists should teach and encourage practices such as deep breathing exercises and airway clearance techniques to enhance lung capacity and prevent pneumonia, which is a common complication due to weakened respiratory muscles.

Inspiratory Muscle Training. This can strengthen the diaphragm and other muscles involved in breathing, helping to maintain adequate ventilation and oxygenation.

Preventing Falls

Balance Training. PTs should train tailored exercises that enhance balance and coordination can help reduce the risk of falls, a significant concern as muscle weakness progresses.

Home Safety Assessments. Physical therapists provide recommendations on home modifications to reduce fall risks, such as securing rugs, installing grab bars, and ensuring adequate lighting.

Skin Integrity

Pressure Relief Techniques. For those who are wheelchair-bound or bedridden, physical therapists instruct on methods to change positions frequently to avoid pressure sores, which are a serious risk due to immobility.

Use of Supportive Devices. Physical therapists should provide recommendations on appropriate cushions, mattresses, and wheelchair adjustments to ensure even

weight distribution and reduce the risk of skin breakdown which may lead to pressure ulcers.

Pain Management

Therapeutic Modalities. Techniques such as heat therapy, cold therapy, or gentle electrical stimulation can help manage pain that may arise from muscle or joint stress.

Section 3 Key Words

Brooke Scale for Upper Extremity Function - A clinical tool used to assess and quantify the functional abilities of the upper extremities in those with muscular dystrophy

Least Restrictive Assistive Device - Equipment that provides necessary aid to an individual while imposing the minimal amount of restriction on independence

Intermediate Stage of MD - A period where symptoms become more pronounced and muscle weakness progresses noticeably, affecting mobility and daily activities more significantly than in the early stages

Section 3 Summary

Physical therapy plays a pivotal role in the management of muscular dystrophy, aiming to maximize functional abilities, optimize safety, enhance mobility, and improve the overall quality of life for those affected by the condition. This section has outlined key orthopedic interventions that address musculoskeletal complications commonly associated with muscular dystrophy, such as contractures and scoliosis. Through stretching exercises, bracing, and the use of orthopedic devices, physical therapists can significantly mitigate these issues.

Multidisciplinary Care Team ^{30,37}

Managing muscular dystrophy requires comprehensive medical care that addresses not only the physical symptoms but also the emotional, psychological, and practical needs of the patient. Having a multidisciplinary care team is paramount, as it brings together various specialists to provide holistic, coordinated, and effective care. It is crucial that all members of the multidisciplinary care team refer patients with MDs to other disciplines. This section will provide insight to the significance of a multidisciplinary care team for individuals with muscular dystrophy, including the roles of physicians, mental health professionals, and occupational therapists, among others.

Physicians - Specialists

Neurologists

Neurologists are the primary specialist in diagnosing and monitoring the progression of MD. The neurologist will guide medical treatment, including medication management and monitoring neurological function. They will lead genetic testing efforts, muscle biopsies, EMG studies, and laboratory levels for the diagnosis of MD. Then, they will prescribe medications, monitor progression, and work within the multidisciplinary care team.

Cardiologist

The involvement of a cardiologist is vital for early detection, ongoing management, and intervention for cardiac-related complications associated with MD. They provide regular cardiac evaluations, ECGs, echocardiograms, and Holter monitoring. They also prescribe medications like ACE inhibitors and beta-blockers

to address heart failure. In some cases, they place pacemakers and implantable cardioverter defibrillators to manage arrhythmia.

Pulmonologist

In the management of muscular dystrophy (MD), the involvement of a pulmonologist is critical, particularly as the disease progresses and affects the respiratory muscles. Pulmonologists perform pulmonary function tests, sleep studies, address ventilatory support and cough assistance, and work directly with respiratory therapists for continual respiratory treatment.

Mental Health Professionals

In the comprehensive care of muscular dystrophy (MD), mental health professionals play a crucial role in addressing the psychological and emotional challenges faced by patients and their families. As MD is a progressive condition that affects physical abilities and independence, it often has significant psychological repercussions. Mental health professionals involved can include psychologists, psychiatrists, and licensed clinical social workers, each providing specialized support tailored to the needs of the individual and their family.

Cognitive behavioral therapy and other talk therapy approaches can assist both the patient and the families cope with the emotional distress of the diagnosis. Support groups and family therapy are also helpful.

Psychiatrists can assess patients for psychiatric symptoms that may be related to or exacerbated by MD, such as mood swings or cognitive changes. They may also prescribe medications and monitor their effects, to manage symptoms of depression, anxiety, or other psychiatric conditions that might occur alongside MD.

Occupational Therapy

Occupational therapists play a vital role in the care of individuals with muscular dystrophy by enhancing their ability to perform everyday activities and maintain independence. They begin with a comprehensive functional assessment to evaluate a patient's capability to handle daily tasks, motor skills, and overall strength. OTs tailor activities to the patient's evolving abilities, teaching new techniques for simpler task completion and recommending adaptive devices such as specialized utensils, dressing aids, and modified keyboards to aid in daily functions. They also suggest home and workplace modifications to improve accessibility and safety, such as installing grab bars and modifying bathrooms. To manage the fatigue associated with MD, OTs provide strategies for energy conservation and work simplification. Furthermore, they offer training and support to both patients and caregivers, enhancing the patient's autonomy. OTs also address the psychological and social aspects of living with MD, encouraging social participation and providing coping strategies. They collaborate with other healthcare professionals to ensure a coordinated and comprehensive approach to care and advocate for the patient's rights and needs, promoting accessibility and engagement in community life.

School - Special Education Teachers

A special education teacher plays a critical role in supporting students with muscular dystrophy within the educational system. Their responsibilities are tailored to meet the unique educational and physical needs of these students, ensuring that they receive an appropriate and effective learning experience.

Special education teachers collaborate with other educators, parents, and healthcare professionals to develop an Individualized Education Plan (IEP) that addresses both the academic goals and the health accommodations needed for

the student. The IEP is reviewed and updated regularly to adapt to the student's changing needs as MD progresses, ensuring that educational goals and accommodations remain relevant and supportive. They help to provide physical accommodations, assistive technologies, and work directly with school PT and OT to provide an optimal learning environment.

Section 4 Key Words

Implantable Cardioverter Defibrillator - a medical device designed to monitor heart rhythm and deliver therapy to correct arrhythmias

Pulmonologist - A physician who specializes in diagnosing, treating, and managing conditions related to the respiratory system

Section 4 Summary

Effective management of MD requires a comprehensive approach that not only addresses the physical manifestations but also the emotional, psychological, and practical challenges faced by patients. The integration of a multidisciplinary care team is crucial, uniting a variety of specialists to deliver holistic, coordinated, and efficient care. This section has highlighted the critical importance of such a team, including physicians, mental health professionals, occupational therapists, and others, in providing optimal support and treatment for individuals with muscular dystrophy.

Case Study 1

Jake is a 10-year-old male who was diagnosed with Duchenne Muscular Dystrophy at age 5. He exhibits progressive lower limb muscle weakness, frequent falls, and difficulty in rising from the floor (utilizing Gower's maneuver), climbing stairs, and

running. The treatment goals aim to prolong his ambulation and functional independence, prevent contractures, and maintain muscle strength without exacerbating muscle breakdown. He has received regular corticosteroid therapy and uses a wheelchair for community ambulation and is able to ambulate household distances with assistance.

Reflection Questions

1. What are good physical therapy interventions for this stage of DMD?
2. How effective is a stretching regimen in slowing the progression of contractures in patients with DMD?
3. Can aquatic therapy provide long-term benefits to DMD patients, considering the progressive nature of the disease?

Responses

1. A daily stretching routine to prevent contractures, low resistance band exercises to preserve lower and upper limb strength, aquatic therapy, and assistive device safety training.
2. Stretching is crucial for maintaining range of motion and preventing contractures. For Jake, the daily stretching routine helps in reducing the rate of contracture development, which is essential for prolonging his ability to perform daily activities independently.
3. Aquatic therapy is highly beneficial for DMD patients due to the reduced gravity environment, which lessens joint and muscle stress during exercise. For Jake, it helps in maintaining muscle function and cardiovascular health, which are vital for his quality of life.

Case Study 2

Maria, a 40-year-old female, presents with advanced myotonic dystrophy, characterized by progressive muscle weakness, myotonia, and severe atrophy. The primary goals of her physical therapy are to maximize her remaining functional abilities, manage symptoms, and enhance her quality of life. She was diagnosed at age 30, has arrhythmias, and uses a manual wheelchair for mobility.

Reflection Questions

1. What are good physical therapy interventions for Maria?
2. How effective are passive range of motion exercises in managing contractures in late-stage MMD?
3. Considering the progressive nature of MMD, how can physical therapy adapt to ensure continuity of care as Maria's condition evolves, particularly with the expected increase in mobility and daily activity limitations?

Responses

1. Passive range of motion exercises, respiratory muscle training, functional mobility training, and pain management techniques should be the focus of care.
2. Passive range of motion exercises are crucial for patients like Maria, who have limited ability to perform active exercises. These exercises help maintain flexibility, reduce the severity of contractures, and are effective in keeping joints functional.
3. As Maria's MMD progresses, her physical therapy needs to adapt dynamically to her evolving requirements. Regular evaluations of her

functional abilities and symptoms are essential to tailor her treatment plan. As her mobility declines, assistive technology like powered wheelchairs or adaptive utensils may be used to sustain her independence. Therapy will also likely focus more on managing pain and discomfort due to increased immobility, using specialized seating and advanced pain management techniques. It's crucial that both Maria and her caregivers are trained to use new assistive technologies and handle any new symptoms effectively.

Conclusion

In conclusion, muscular dystrophy presents a complex spectrum of genetic disorders characterized by progressive muscle weakness and degeneration, with several stages of challenges. This course has explored the types of MD, diagnosis, treatment modalities, formulation of individualized care plans, management of mobility challenges, impacts on various body systems, and the disease's ramifications on daily life. Armed with this knowledge, PTs and PTAs are equipped to develop personalized care plans that address the distinct needs, goals, and disease progression of each patient. By implementing various interventions, therapists can empower individuals with muscular dystrophy to enhance their quality of life. With dedication and expertise, the medical community, including rehabilitation, can continue to make meaningful strides in supporting and improving the well-being of those affected by this complex condition.

References

1. Salari N, Fatahi B, Valipour E, et al. Global prevalence of Duchenne and Becker muscular dystrophy: a systematic review and meta-analysis. *J Orthop Surg.* 2022;17(1):96. doi:10.1186/s13018-022-02996-8
2. Butterfield RJ. Congenital Muscular Dystrophy and Congenital Myopathy. *Contin Minneap Minn.* 2019;25(6):1640-1661. doi:10.1212/CON.0000000000000792
3. Sherief AEAA, Abd ElAziz HG, Ali MS. Efficacy of two intervention approaches on functional walking capacity and balance in children with Duchene muscular dystrophy. *J Musculoskelet Neuronal Interact.* 2021;21(3):343-350.
4. M B, Am P. Genetics, X-Linked Inheritance. PubMed. Published January 2024. Accessed April 6, 2024. <https://pubmed.ncbi.nlm.nih.gov/32491315/>
5. Sattenapalli NC, Areti AR, G SNKR, Kulandaivelu US, Alavala RR, Manne R. Study of Clinical Features and Diagnosis Pattern of Duchene Muscular Dystrophy in Southern India. *J Neurosci Rural Pract.* 2022;13(1):43-49. doi:10.1055/s-0041-1740614
6. Duchenne Muscular Dystrophy. Physiopedia. Accessed April 6, 2024. https://www.physio-pedia.com/Duchenne_Muscular_Dystrophy
7. Demirci H, Durmus H, Toksoy G, Uslu A, Parman Y, Hanagasi H. Cognition of the mothers of patients with Duchenne muscular dystrophy. *Muscle Nerve.* 2020;62(6):710-716. doi:10.1002/mus.27057
8. Straub V, Guglieri M. An update on Becker muscular dystrophy. *Curr Opin Neurol.* 2023;36(5):450-454. doi:10.1097/WCO.0000000000001191

9. Magot A, Wahbi K, Leturcq F, et al. Diagnosis and management of Becker muscular dystrophy: the French guidelines. *J Neurol*. 2023;270(10):4763-4781. doi:10.1007/s00415-023-11837-5
10. Limb girdle muscular dystrophy 2B (LGMD2B) - Overview | Muscular Dystrophy UK. Accessed April 6, 2024. <https://www.muscular dystrophyuk.org/conditions/limb-girdle-muscular-dystrophy-2b-lgmd2b>
11. Progression to Loss of Ambulation Among Patients with Autosomal Recessive Limb-girdle Muscular Dystrophy: A Systematic Review - PMC. Accessed April 6, 2024. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9398075/>
12. Muni-Lofra R, Juanola-Mayos E, Schiava M, et al. Longitudinal Analysis of Respiratory Function of Different Types of Limb Girdle Muscular Dystrophies Reveals Independent Trajectories. *Neurol Genet*. 2023;9(4):e200084. doi:10.1212/NXG.0000000000200084
13. Mocciaro E, Giamb Bruno R, Micheloni S, et al. WDR5 is required for DUX4 expression and its pathological effects in FSHD muscular dystrophy. *Nucleic Acids Res*. 2023;51(10):5144-5161. doi:10.1093/nar/gkad230
14. Outcome Measures in Facioscapulohumeral Muscular Dystrophy Clinical Trials - PMC. Accessed April 6, 2024. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8870318/>
15. Myotonic Dystrophy (DM) - Diseases. Muscular Dystrophy Association. Published December 18, 2015. Accessed April 9, 2024. <https://www.mda.org/disease/myotonic-dystrophy>
16. Myotonic Dystrophy: What It Is, Symptoms, Types & Treatment. Cleveland Clinic. Accessed April 9, 2024. <https://my.clevelandclinic.org/health/diseases/24516-myotonic-dystrophy-dm>

17. Ji H. Myotonic Dystrophy. *Contin Minneap Minn*. 2022;28(6). doi:10.1212/CON.0000000000001184
18. Pasrija D, Tadi P. Congenital Muscular Dystrophy. In: *StatPearls [Internet]*. StatPearls Publishing; 2023. Accessed April 9, 2024. <https://www.ncbi.nlm.nih.gov/books/NBK558956/>
19. Facioscapulohumeral Muscular Dystrophy (FSH, FSHD) - Diseases. Muscular Dystrophy Association. Published December 18, 2015. Accessed April 9, 2024. <https://www.mda.org/disease/facioscapulohumeral-muscular-dystrophy>
20. Duchenne Muscular Dystrophy (DMD) - Diseases. Muscular Dystrophy Association. Published November 17, 2017. Accessed April 9, 2024. <https://www.mda.org/disease/duchenne-muscular-dystrophy>
21. Becker Muscular Dystrophy (BMD) - Diseases | Muscular Dystrophy Association. Accessed April 9, 2024. <https://www.mda.org/disease/becker-muscular-dystrophy>
22. Mogharehabet F, Czubryt MP. The role of fibrosis in the pathophysiology of muscular dystrophy. *Am J Physiol Cell Physiol*. 2023;325(5):C1326-C1335. doi:10.1152/ajpcell.00196.2023
23. Mercuri E, Bönnemann CG, Muntoni F. Muscular dystrophies. *Lancet Lond Engl*. 2019;394(10213):2025-2038. doi:10.1016/S0140-6736(19)32910-1
24. Narasimhaiah D, Uppin MS, Ranganath P. Genetics and muscle pathology in the diagnosis of muscular dystrophies: An update. *Indian J Pathol Microbiol*. 2022;65(Supplement):S259-S270. doi:10.4103/ijpm.ijpm_1074_21
25. Punga AR, Maddison P, Heckmann JM, Guptill JT, Evoli A. Epidemiology, diagnostics, and biomarkers of autoimmune neuromuscular junction disorders. *Lancet Neurol*. 2022;21(2):176-188. doi:10.1016/S1474-4422(21)00297-0

26. Electrodiagnostic Assessment of Motor Neuron Disease - PubMed. Accessed April 17, 2024. <https://pubmed.ncbi.nlm.nih.gov/34602215/>
27. Lundberg IE, Fujimoto M, Vencovsky J, et al. Idiopathic inflammatory myopathies. *Nat Rev Dis Primer*. 2021;7(1):86. doi:10.1038/s41572-021-00321-x
28. Younger DS. Congenital myopathies. *Handb Clin Neurol*. 2023;195:533-561. doi:10.1016/B978-0-323-98818-6.00027-3
29. Doughty CT, Amato AA. Toxic Myopathies. *Contin Minneap Minn*. 2019;25(6):1712-1731. doi:10.1212/CON.0000000000000806
30. Duan D, Goemans N, Takeda S, Mercuri E, Aartsma-Rus A. Duchenne muscular dystrophy. *Nat Rev Dis Primer*. 2021;7(1):13. doi:10.1038/s41572-021-00248-3
31. Caputo V, Megalizzi D, Fabrizio C, et al. Update on the Molecular Aspects and Methods Underlying the Complex Architecture of FSHD. *Cells*. 2022;11(17):2687. doi:10.3390/cells11172687
32. Georganopoulou DG, Moisiadis VG, Malik FA, et al. A Journey with LGMD: From Protein Abnormalities to Patient Impact. *Protein J*. 2021;40(4):466-488. doi:10.1007/s10930-021-10006-9
33. Gianola S, Castellini G, Pecoraro V, Monticone M, Banfi G, Moja L. Effect of Muscular Exercise on Patients With Muscular Dystrophy: A Systematic Review and Meta-Analysis of the Literature. *Front Neurol*. 2020;11:958. doi:10.3389/fneur.2020.00958
34. Leone E, Pandyan A, Rogers A, Kulshrestha R, Hill J, Philp F. Effectiveness of conservative non-pharmacological interventions in people with muscular dystrophies: a systematic review and meta-analysis. *J Neurol Neurosurg Psychiatry*. 2024;95(5):442-453. doi:10.1136/jnnp-2023-331988

35. Voet NB, van der Kooi EL, van Engelen BG, Geurts AC. Strength training and aerobic exercise training for muscle disease. *Cochrane Database Syst Rev.* 2019;2019(12):CD003907. doi:10.1002/14651858.CD003907.pub5
36. Willcocks RJ, Barnard AM, Wortman RJ, et al. Development of Contractures in DMD in Relation to MRI-Determined Muscle Quality and Ambulatory Function. *J Neuromuscul Dis.* 2022;9(2):289-302. doi:10.3233/JND-210731
37. CDC. What is Muscular Dystrophy? | CDC. Centers for Disease Control and Prevention. Published November 27, 2019. Accessed June 18, 2022. <https://www.cdc.gov/ncbddd/musculardystrophy/facts.html>



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