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Review

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Evaluating Grasp Function in Patients With Chronic Inflammatory Demyelinating Polyneuropathy Using Dynamometers: A Comprehensive Review

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Abstract

Chronic inflammatory demyelinating polyneuropathy (CIDP) is a progressive neurological disorder characterized by weakness and impaired sensory function due to damage to peripheral nerves. Evaluating grasp function is critical for understanding the impact of CIDP on patients' daily activities and guiding rehabilitation strategies. This comprehensive review examines the role of dynamometers in quantifying grip strength deficits, tracking disease progression, and assessing treatment outcomes in CIDP patients. Key findings highlight the utility of dynamometers in quantifying grip strength deficits, tracking disease progression, and evaluating treatment outcomes. The review also explores methodological considerations, such as standardizing testing protocols and integrating dynamometric measurements with clinical scales. By providing insights into the functional impairments associated with CIDP and the effectiveness of therapeutic interventions, this review underscores the role of dynamometry in advancing patient care and enhancing the quality of life for individuals living with this condition. Future research directions include the development of more sensitive dynamometric tools and longitudinal studies to better understand the relationship between grip strength and overall disease trajectory in CIDP.

Keywords: CIDP; Grasp function; Dynamometers; Grip strength; Neurological disorders; Functional assessment

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Introduction

Chronic inflammatory demyelinating polyneuropathy (CIDP) is a rare, immune-mediated neuropathy characterized by progressive or relapsing weakness and sensory loss due to demyelination of peripheral nerves. CIDP is widely acknowledged as the most prevalent chronic immune-mediated neuropathy. It encompasses a spectrum of clinical subtypes, including typical CIDP, multifocal, distal, and motor-predominant forms, each with distinct pathophysiological mechanisms. Typical CIDP involves symmetrical motor and sensory deficits with a chronic, progressive, or relapsing course. In contrast, multifocal motor neuropathy, distal acquired demyelinating symmetric neuropathy (DADS), and focal or multifocal forms may exhibit asymmetrical, distal, or purely motor involvement. These subtypes reflect heterogeneity in the immune-mediated mechanisms underlying nerve damage, influencing clinical manifestation and therapeutic response, underscoring the need for tailored diagnostic and management approaches [1, 2].

Patients with CIDP commonly present with symmetric muscle weakness affecting both proximal and distal muscle groups, leading to difficulty walking, climbing stairs, or gripping objects. Proximal involvement challenges activities requiring shoulder or hip strength, while distal weakness impacts fine motor skills and balance. Sensory disturbances include sensory loss, tingling (paresthesia), and pain. Symptoms often follow a length-dependent pattern, starting in the extremities and progressing proximally. Sensory deficits involve diminished vibratory sensation, reduced proprioception, and impaired tactile discrimination, significantly affecting balance and coordination. Neuropathic pain, described as burning, stabbing, or electric shock-like sensations, further contributes to discomfort. These symptoms result from immune-mediated demyelination and axonal damage affecting sensory and motor nerve fibers. Early detection and comprehensive management are crucial to alleviating these debilitating effects [1].

CIDP encompasses several distinct variants. Multifocal CIDP is characterized by asymmetrical involvement, often mimicking conditions like multifocal motor neuropathy. Distal CIDP (DADS) predominantly affects distal extremities, presenting as sensory deficits and weakness in a glove-and-stocking distribution. Motor CIDP primarily involves motor

deficits and sparing sensory nerves and may resemble motor neuropathies such as amyotrophic lateral sclerosis (ALS). Each subtype reflects differences in immune targeting of myelin or axons, influencing clinical course, diagnostic approach, and response to therapy. Recognizing these variants is essential for personalized treatment strategies and improving patient outcomes [1, 3].

Hand function is essential for daily tasks, encompassing a range of movements critical for cooking, dressing, and driving. Grasp strength, integral for manipulating objects, is crucial in maintaining independence. Fine motor skills enable intricate movements like buttoning clothes, while gross motor abilities support actions like steering or carrying objects. Hand functionality directly affects quality of life, especially in conditions impairing neuromuscular control or strength, such as CIDP [4]. Hands also serve as a medium for nonverbal communication and tactile exploration. Gestures like waving or pointing facilitate interaction, while tactile engagement builds emotional connections and trust. Damage to hand function can significantly impact daily activities, requiring adaptive tools or caregiver assistance, emphasizing the need for early rehabilitation and innovative device designs [5].

Evaluating hand function is vital for understanding neuromuscular impairment and tailoring rehabilitation. Tools such as the Duruoz Hand Index (DHI) measure deficits in mobility, strength, and dexterity, guiding targeted interventions to enhance independence. Damage to hand function often necessitates adaptive devices, which still require baseline grip strength to operate effectively. Comprehensive assessment and tailored rehabilitation programs are essential to restore functional autonomy and improve quality of life [6].

Aging often brings declines in hand strength and dexterity due to muscle atrophy, reduced nerve conduction velocity, and joint stiffness. This impacts tasks requiring grip strength, such as opening jars or carrying groceries, challenging older adults' independence. Grasp strength serves as an indicator of overall functionality and is linked to fall risk and frailty. Adaptive tools like walkers and canes demand foundational grip strength, making targeted exercises and ergonomic designs critical for preserving autonomy and quality of life [4].

Regular monitoring of grip strength is crucial for managing CIDP patients undergoing treatments such as intravenous immunoglobulin (IVIG) therapy. Periodic assessments provide real-time insights into muscle strength fluctuations, enabling timely adjustments to treatment plans. This proactive approach enhances therapeutic efficacy and individualizes care, optimizing outcomes [7]. The DHI and the 16-grasp test effectively evaluate hand function in CIDP patients. These tools assess deficits in fine and gross motor skills, aiding in rehabilitation planning. The DHI evaluates daily activity performance, while the 16-grasp test identifies grip strength and coordination impairments. Adapting these tools to CIDP provides nuanced insights for personalized therapy [8].

Advanced neuroprosthetic systems integrating dynamometry and electromyography (EMG) offer comprehensive evaluations of hand function. Dynamometers measure grip strength, while EMG tracks muscle activation patterns, identifying fatigue or diminished motor control. These technologies enhance understanding of motor impairments and guide personalized rehabilitation strategies [9]. Reviewing over 15 validated tools highlights the importance of tailoring assessments to patient needs. Factors like symptom severity, physical abilities, and clinical goals determine tool selection, ensuring accurate evaluations and optimized treatment plans [10].

Methodology

A systematic literature review was conducted, focusing on studies that employed dynamometers to assess grip strength in CIDP patients. Inclusion criteria encompassed peer-reviewed clinical trials, observational studies, and reviews evaluating grip strength in CIDP. Studies that did not report methodology or lacked comparative grip strength assessments were excluded. Data were analyzed to identify patterns in grip strength deficits, response to interventions, and the effectiveness of dynamometric assessments.

Pathophysiology of CIDP and Its Impact on Hand Function

CIDP is characterized by immune-mediated damage to peripheral nerves, leading to significant motor and sensory impairments. The pathophysiology of CIDP involves both humoral and cellular immune responses, with variations across its clinical subtypes impacting hand function. Understanding these mechanisms is crucial for developing effective treatments and improving patient outcomes.

CIDP is primarily driven by an abnormal immune response, where T cells and autoantibodies play a central role in targeting and attacking myelin components. This immune-mediated process leads to inflammation and subsequent damage to the protective myelin sheath surrounding peripheral nerves. The underlying mechanism of this immune response is thought to involve molecular mimicry, where the immune system mistakenly identifies components of the peripheral nervous system as foreign, triggering an inflammatory cascade. This results in demyelination, impairing nerve conduction and causing the motor and sensory deficits typical of CIDP [11].

CIDP leads to demyelination at both the nerve roots and distal nerve terminals, which are particularly vulnerable in areas where the blood-nerve barrier is compromised. This barrier dysfunction allows immune cells and antibodies to infiltrate nerve tissue, attacking and damaging the myelin sheath. The affected nerves experience reduced conduction velocity and functional impairments as myelin is lost. The resulting slowed or blocked nerve signals contribute to the condition's progressive weakness, sensory disturbances, and reflex loss. These areas of demyelination often exhibit chronic inflammation and remyelination failure, leading to ongoing nerve dysfunction [1].

CIDP manifests in various clinical variants, exhibiting unique pathophysiological characteristics influencing disease progression and symptom presentation. In multifocal CIDP, focal areas of demyelination occur in multiple nerve segments, leading to asymmetrical motor deficits and sensory loss that may mimic conditions such as multifocal motor neuropathy.

This variant is often marked by discrete nerve involvement and may present with motor impairment before sensory changes. In contrast, distal CIDP is characterized by length-dependent symptoms, where the distal limbs, such as the hands and feet, are affected first, with symptoms progressing proximally as the disease advances. This variant commonly presents with sensory loss and weakness in a glove-and-stocking distribution, indicating the involvement of the longest nerve fibers. The distinct pathological features of each variant, including patterns of demyelination and the regions of the nervous system most affected, underscore the complexity of CIDP and the importance of accurate diagnosis and personalized treatment strategies [2, 12].

Patients with CIDP often experience symmetric muscle weakness, which can significantly impair both grip strength and fine motor skills. This weakness typically begins in the proximal muscles and progresses distally, affecting major muscle groups responsible for essential movements. As the condition advances, individuals may struggle with basic tasks such as holding objects, typing, or performing delicate activities like buttoning a shirt or writing. The impact on grip strength is particularly disabling, as it affects daily tasks and compromises independence and quality of life. The weakness results from immune-mediated demyelination of peripheral motor neurons, leading to slowed or blocked nerve conduction, directly impacting muscle activation and coordination [7].

Regularly monitoring grip strength is crucial to managing CIDP, as it provides valuable insights into treatment efficacy and the degree of functional impairment over time. By using tools such as dynamometers or other objective grip strength measures, clinicians can track changes in muscle strength and detect subtle improvements or declines. These data aid in making real-time adjustments to treatment plans, such as modifying dosages of IVIG or other therapeutic interventions. In addition to assessing grip strength, such monitoring helps evaluate broader functional capabilities, including fine motor coordination and task-specific performance, which are essential for maintaining independence. By regularly tracking these metrics, healthcare providers can more accurately tailor rehabilitation efforts and optimize patient outcomes [7].

Grasp Function and Its Assessment

The grasp function encompasses several critical components, including strength, coordination, and endurance, essential for practical hand function during various tasks. Studies confirm that CIDP patients exhibit significantly reduced grip strength compared to healthy individuals. Variability in grip performance correlates with disease progression and therapy response, particularly for IVIG and rehabilitation interventions. Understanding these components is vital for assessing hand functionality and developing rehabilitation strategies. The following sections elaborate on these key aspects.

Grasp strength refers to the force exerted by the hand when holding or manipulating an object, and it is a critical indicator of hand function. This strength is essential for performing various tasks, from basic activities like holding utensils to more complex actions such as lifting heavy objects or using tools. Dynamometers are commonly used to measure grasp strength, quantitatively assessing pinch strength (the force generated by the thumb and finger) and full-hand grip strength (the force generated by the entire hand). These measurements allow clinicians to objectively track a patient's progress, identify impairments, and monitor changes in response to treatment or rehabilitation efforts [13].

Different types of grips contribute to the overall strength and dexterity required for functional hand use. Tip pinch, where the thumb and fingertip come together, is crucial for delicate tasks that require precision, such as picking up small objects or writing. Tri-digit pinch, involving the thumb, index, and middle fingers, is often used for tasks that require more force but still demand fine motor control, such as holding a pencil or opening a bottle. Lateral pinch, where the thumb and the side of the index finger work together, is essential for tasks that involve holding objects firmly, such as carrying bags or turning keys. These various pinch types are indispensable for daily activities and contribute to a person's ability to function independently. Each grip requires specific motor coordination and strength, and the ability to assess these components is key in diagnosing and treating conditions that impair hand function [13].

Coordination is the complex integration of sensory and motor functions, enabling individuals to execute smooth, precise movements essential for daily activities. It allows the body to respond effectively to sensory feedback, adjusting motor output in real-time. In the context of hand function, this coordination is significant for tasks that involve reaching and grasping. Studies suggest that the coordination between these two components, reach (transporting the hand to an object) and grasp (securing the object), is not the result of a fixed motor program but a dynamic sensorimotor process. This process involves continuous adjustments based on sensory input, such as visual or tactile feedback, which fine-tune motor actions and ensure accurate execution of complex tasks [14].

The neural substrates responsible for coordinating these actions are primarily located in brain areas such as the dorsal premotor cortex. This brain region plays a key role in planning and executing voluntary movements, particularly in object manipulation and hand-eye coordination tasks. It integrates sensory information, such as the position of the hand relative to an object, with motor commands that control the reach and grasp movements. Additionally, the dorsal premotor cortex communicates with other regions, including the parietal and motor cortex, to ensure smooth, adaptive, and efficient reach-to-grasp actions. This complex network allows for the fluid execution of tasks that require fine motor control and coordination, such as picking up a cup or typing on a keyboard [15].

Endurance in grasp function refers to the ability to sustain grip strength over an extended period, enabling individuals to perform tasks that require prolonged holding or manipulation of objects. This aspect of hand function is crucial in everyday activities such as holding a suitcase, maintaining a steady grip while typing, or using tools for extended periods. Unlike static grip strength, which measures the maximum force exerted at a single point, endurance reflects the ability to resist fatigue and maintain practical hand function throughout a task. As such, it

plays a critical role in functional independence, as many daily tasks require the ability to hold or manipulate objects continuously without significant loss of performance or strength [13].

The endurance assessment is essential for understanding the overall functional capacity of the hand, particularly in patients recovering from neurological or musculoskeletal conditions. This evaluation can reveal deficits in muscle stamina or motor control that may not be apparent through traditional strength measures alone. In rehabilitation, assessing endurance provides valuable insights into how well a patient can perform tasks that involve sustained effort, guiding the development of personalized rehabilitation strategies. Improving grip endurance through targeted therapies, such as strength training or neuromuscular re-education, can profoundly impact rehabilitation outcomes, enhancing a patient's ability to engage in prolonged activities and improving their quality of life. Monitoring endurance over time also helps evaluate the effectiveness of interventions and adjust treatment plans to optimize recovery [13].

Dynamometers are essential for assessing grasp strength, particularly in clinical and rehabilitation settings. They provide objective measurements that can inform diagnoses and treatment plans for various conditions.

Hand-held dynamometers are widely used tools for quantifying muscle strength across various muscle groups, focusing on grip strength. These devices are integral to clinical assessments, rehabilitation monitoring, and research studies, providing an objective measure of muscle performance. However, studies have highlighted variability in measurements across different models. For instance, the Jamar dynamometer is considered a gold standard, and newer models, like the K-force dynamometer, often yield differing results due to design, calibration, and user handling variations. These discrepancies underline the importance of standardizing measurement protocols and selecting appropriate tools based on the patient population and clinical objectives [16, 17].

The advent of digital dynamometers, such as the Jamar Plus, has introduced advanced features like real-time data visualization and increased precision, facilitating more nuanced assessments. Digital dynamometers enhance precision, offering real-time data visualization. However, standardization in testing protocols is needed to ensure consistency across studies and clinical settings. Comparisons between digital and traditional analogue models have revealed notable differences in grip strength measurements, particularly in older adults. Digital devices provide more consistent and reproducible results, but their sensitivity may sometimes exaggerate subtle strength variations, potentially affecting clinical interpretations. Older adults, who may exhibit fluctuations in grip strength due to age-related changes, benefit from the accuracy of digital dynamometers in capturing finer details of muscle performance. Despite these advantages, analogue models remain favored in some settings due to their simplicity, lower cost, and familiarity among practitioners. These findings emphasize the need to consider patient characteristics and the specific measurement goals when choosing between digital and analog devices [18, 19].

Studies on inter-instrument reliability highlight significant differences in performance across various dynamometer models. While some devices demonstrate high reliability, with intraclass correlation coefficients (ICCs) exceeding 0.96, their measurements may still deviate from those obtained using reference standards, often underestimating actual grip strength values. Such underestimation can influence the evaluation of a patient's muscle function and potentially impact clinical decision-making, particularly in conditions where precise strength assessment is crucial, such as rehabilitation or neuromuscular disorders. These findings underscore the importance of validating new dynamometer models against established reference devices to ensure measurement accuracy and clinical applicability [17]. The variability in grip strength measurements across different dynamometers presents challenges in clinical practice. This variability can lead to discrepancies in strength assessments, potentially resulting in divergent interpretations of a patient's functional capacity or treatment progress. Such inconsistencies emphasize the necessity of consistently using the same dynamometer model for serial assessments within the same patient. Adopting a standardized protocol for measurement, including hand positioning, grip span adjustment, and patient instructions, further enhances reliability and minimizes variability. By ensuring consistency in device usage and measurement practices, clinicians can achieve more accurate and comparable results over time, enabling better monitoring of rehabilitation outcomes and disease progression [18].

Findings on Dynamometer Use in CIDP

Various studies have explored the use of dynamometers to assess muscle strength in patients with CIDP, highlighting their effectiveness in monitoring functional recovery and treatment outcomes. These studies demonstrate that dynamometers can provide objective measurements of muscle strength, which are crucial for evaluating the impact of therapies such as IVIG and exercise interventions.

A study by Opala et al [20] utilized dynamometers to evaluate strength changes in CIDP patients undergoing IVIG therapy. The study measured strength across multiple muscle groups, including handgrip, knee extension, elbow flexion, and ankle dorsiflexion, providing a comprehensive assessment of functional recovery. Notably, handgrip strength demonstrated the earliest and most significant recovery, highlighting its sensitivity as a marker for treatment efficacy. These findings underscore the utility of dynamometry not only in tracking motor improvement but also in identifying early therapeutic responses, which are critical for optimizing patient care and adjusting treatment strategies.

The GRIPPER study further exemplifies the practical application of dynamometers in clinical and home settings. This study focuses on daily grip strength fluctuations in CIDP patients receiving home-based IVIG infusions, offering insights into the variability of motor function during treatment cycles. By integrating dynamometers into routine care, clinicians can monitor real-time changes in grip strength, facilitating early detection of potential relapses or suboptimal therapeutic responses. Daily monitoring empowers patients to engage in their care actively, providing valuable feedback for individualized treatment adjustments. The GRIPPER study highlights how portable and user-friendly dynamometers can enhance the

management of CIDP in both clinical and home environments, bridging the gap between periodic assessments and continuous monitoring [21].

Research has demonstrated that resistance and aerobic exercise programs can significantly improve muscle strength and aerobic capacity in patients with CIDP. Markvardsen et al [22] used isokinetic dynamometry to track muscle performance, showing that patients who engaged in structured exercise regimens experienced measurable strength gains. Importantly, follow-up assessments revealed that those who maintained their exercise routines could sustain these improvements over time. This highlights the critical role of ongoing physical activity in preventing deconditioning and maintaining functional independence in CIDP patients.

Dynamometers have emerged as essential tools in understanding the multifactorial nature of muscle weakness in CIDP. Gilmore et al [23] highlighted the importance of dynamometry in evaluating muscle atrophy and neuromuscular transmission stability. These measurements provided detailed insights into the underlying mechanisms of muscle weakness, which involve a combination of denervation, demyelination, and impaired synaptic transmission. By accurately quantifying changes in muscle strength and performance, dynamometers not only aid in diagnosing atrophy and neuromuscular instability but also help tailor rehabilitation strategies to address these specific deficits. This underscores their utility as a diagnostic and therapeutic monitoring tool in managing CIDP.

Patients with CIDP commonly exhibit marked reductions in grip strength, a functional metric strongly associated with overall muscle health and neuromuscular function. Grip strength is a reliable clinical indicator of disease severity and progression, offering insights into the patient's ability to perform daily activities requiring fine motor skills and sustained hand use. Studies by Van Veen et al [24] and Cook et al [7] emphasize its utility in assessing functional impairment and tracking responses to interventions such as IVIG therapy or physical rehabilitation. Given its sensitivity to changes in motor function, grip strength remains a cornerstone in evaluating and managing CIDP patients.

Beyond grip strength, muscle atrophy and decreased muscle quality significantly contribute to functional limitations in CIDP. Advanced imaging studies, such as magnetic resonance imaging (MRI), provide detailed assessments of muscle morphology, revealing that CIDP patients exhibit 36% lower isometric strength and 17% smaller muscle volumes than healthy individuals. These findings, reported by Gilmore et al [25], suggest a dual impact: muscle atrophy, reflecting a reduction in muscle size due to denervation and inactivity, and compromised muscle quality, indicative of fatty infiltration, fibrosis, and disrupted neuromuscular transmission. This structural and functional decline reduces strength and affects endurance and coordination, highlighting the importance of targeted interventions to preserve muscle health. By combining grip strength measurements with advanced imaging, clinicians can better understand the multifactorial nature of motor deficits in CIDP and develop more precise therapeutic strategies.

Patients with CIDP often exhibit pronounced gait abnormalities, significantly impacting their mobility and overall quality of life. These impairments include shortened stride lengths, reduced walking speed, and prolonged gait cycle times, reflecting the combined effects of muscle weakness, sensory deficits, and impaired motor coordination. Such gait disturbances hinder daily activities and increase the risk of falls, posing a significant safety concern for individuals with CIDP. A study by Bozovic et al [26] highlights the importance of assessing gait patterns in CIDP as part of a comprehensive approach to understanding mobility limitations and designing targeted rehabilitation programs. Interventions, such as physical therapy, balance training, and assistive devices, are crucial in addressing these gait abnormalities to enhance functional independence and reduce fall-related injuries.

In addition to the motor and large fiber dysfunction, small fiber neuropathy plays a significant role in the sensory disturbances experienced by CIDP patients. Damage to tiny nerve fibers, responsible for transmitting pain and temperature sensations, contributes to a spectrum of symptoms, including neuropathic pain, burning sensations, and hypersensitivity, which can profoundly affect a patient's daily functioning and quality of life. In addition, small fiber involvement exacerbates sensory dysfunction, complicating tasks that require precise proprioceptive input, such as walking or gripping objects [27]. This aspect of CIDP underscores the multifactorial nature of the disease, necessitating a multidisciplinary approach to management, including pain control, sensory retraining, and tailored functional rehabilitation to optimize patient outcomes.

While CIDP predominantly manifests as muscle weakness and functional impairments, the disease's course is often characterized by fluctuations in severity, particularly in response to treatment regimens. These variations may include periods of improvement following therapies such as IVIG or steroids, interspersed with potential relapses or plateaus. Such dynamic changes can complicate accurately assessing strength and function over time, as improvements might be temporary or uneven across different muscle groups.

A study by Cook et al [7] highlights clinicians' challenges distinguishing between genuine disease progression, treatment-induced changes, and natural variability. This underscores the importance of frequent and consistent evaluations using objective tools such as dynamometers or functional performance tests to monitor patient progress. Longitudinal tracking enables clinicians to make data-driven adjustments to treatment plans, ensuring that interventions remain aligned with the patient's evolving condition. Additionally, involving patients in self-monitoring, such as tracking grip strength or endurance at home, can provide real-time feedback, fostering a more responsive and proactive management approach.

Various studies have explored the reliability and validity of dynamometer measurements in patients with CIDP, highlighting the effectiveness of both hand-held and isokinetic dynamometry. These assessments are crucial for evaluating muscle strength and functional status in CIDP patients, although the quality of evidence varies across different neuromuscular diseases.

Hand-held dynamometry, particularly the Jamar hand-held grip dynamometer, has been shown to offer high reliability and validity in assessing muscle strength in patients with CIDP. Research by Rajabally and Narasimhan [28] found a strong correlation between grip strength measurements obtained from the Jamar device and motor and sensory scores, key indicators of

overall neurological function in CIDP patients. This suggests that handgrip strength, as measured by hand-held dynamometry, is a valuable proxy for evaluating the global neurological status of individuals with CIDP. Given its non-invasive, easy-to-use nature, the Jamar dynamometer is particularly useful in clinical settings where frequent monitoring of patient status is essential. The strong correlation with motor and sensory function further supports its utility as an objective tool for assessing the progression of the disease or response to treatments such as IVIG. Additionally, its ability to capture subtle changes in muscle strength makes it an effective measure for identifying early signs of relapse or improvement, allowing for more tailored and responsive treatment adjustments.

Hand-held grip dynamometry has proven to be a valuable tool for assessing muscle strength in CIDP patients, demonstrating significant correlations with electrophysiological measures and functional clinical scores. Research by Rajabally and Narasimhan [28] confirmed that grip strength, as measured by dynamometers, aligns closely with nerve conduction studies and other neurological assessments, reinforcing its validity as an indicator of motor function in CIDP. The device's ability to capture muscle performance provides an objective, quantifiable measure consistent with more invasive, complex diagnostics. It is a reliable and non-invasive option for tracking disease progression, evaluating treatment efficacy, and detecting subtle changes in a patient's condition over time. The correlation with functional scores further underscores its role in assessing the impact of CIDP on a patient's overall mobility and quality of life, offering clinicians an effective tool to guide therapeutic decisions.

Compared to normative grip strength values, CIDP patients exhibit significantly lower grip strength, with their measurements often falling below the median but closer to the fifth percentile for healthy individuals. These findings, highlighted by Rajabally and Narasimhan [28], suggest that while CIDP patients experience considerable muscle weakness, their grip strength can still be a realistic benchmark for treatment goals. The lower-than-average grip strength observed in dynamometer assessments is crucial in diagnosing and monitoring CIDP by providing objective muscle strength and functional ability measures. These assessments, particularly isokinetic dynamometry, have been shown to correlate with clinical outcomes and treatment responses, making them valuable tools in clinical practice.

These patients provide a reference point for clinicians to assess functional recovery over time. Additionally, setting treatment goals based on the fifth percentile as a target may provide a more achievable and clinically relevant standard for rehabilitation and therapeutic interventions instead of aiming for normalized strength levels that might be unrealistic given the chronic nature of CIDP. This approach helps set pragmatic and patient-centered goals, focusing on improving functional capacity and reducing disability rather than purely striving for complete recovery of normal strength.

Role of Dynamometer Assessments in the Diagnosis and Monitoring of CIDP

Dynamometers, such as the Biodex System 3 PRO, provide an exact and objective method for quantifying muscle force, making them invaluable in the clinical management of CIDP. These devices offer detailed assessments of isometric and isokinetic muscle strength, enabling clinicians to accurately evaluate baseline impairments, monitor disease progression, and assess the efficacy of therapeutic interventions.

According to Dyck [29], the precise measurements generated by advanced dynamometry systems are critical for detecting subtle changes in muscle performance that may not be evident through subjective evaluation or manual muscle testing. This level of accuracy is fundamental in CIDP, where treatment responses, such as improvements following IVIG or corticosteroid therapy, can vary significantly across individuals. Tools like the Biodex System 3 PRO support evidence-based decision-making by providing reproducible and quantifiable data, facilitating tailored rehabilitation strategies and ensuring treatment plans align with a patient's evolving needs. Additionally, using such devices in research settings helps standardize strength measurements, advancing the understanding of CIDP pathophysiology and developing more effective therapeutic approaches.

Dynamometers are highly sensitive tools for monitoring treatment responses in patients with CIDP. Studies, including those by Dyck [29], reveal that muscle force measurements captured by these devices show significant fluctuations corresponding to changes in disease status. For example, when treatment is withheld, such as during pauses in IVIG or steroid therapy, measurable declines in muscle strength often occur, reflecting disease progression or relapse. Conversely, upon reinitiation of treatment, dynamometry data typically indicate marked improvements in muscle force, demonstrating the effectiveness of the therapeutic intervention.

This dynamic responsiveness underscores the utility of dynamometers in capturing subtle, real-time changes in neuromuscular function, providing clinicians with a reliable method to evaluate the efficacy of ongoing treatments. Regular monitoring with dynamometry not only aids in identifying treatment-related improvements but also serves as an early warning system for deterioration, enabling timely adjustments to therapeutic strategies. Additionally, these objective and quantifiable data enhance patient care by offering insights into the dose-response relationship, optimizing treatment regimens, and ultimately contributing to better long-term outcomes in CIDP management.

Sophisticated systems included fiber optics-based sensors, motion capture devices, such as the Vicon [30-32], and inertial measurement sensors, which gave the position and orientation of each digit in a 3D space [32-36].

Changes in muscle force, as quantified by dynamometers, have been closely linked to significant gains in functional abilities in CIDP patients. Studies, including those by Dyck [29], demonstrate that improvements in muscle strength often correlate with enhancements in walking velocity, hand dexterity, and overall motor function. These associations underscore the critical role of dynamometry not only in measuring isolated muscle performance and reflecting real-world functional improvements that directly impact a patient's mobility, independence, and quality of life.

By capturing precise changes in grip strength, lower limb force, or other targeted metrics, dynamometers provide action-

able insights into a patient's rehabilitation progress. For instance, increased walking velocity can signify enhanced lower limb strength and coordination, while improved hand function may indicate better fine motor control and grasping ability. Such functional metrics are particularly relevant for evaluating the effectiveness of treatments, such as IVIG, plasmapheresis, or physical therapy, and for tailoring interventions to maximize patient outcomes. Furthermore, the ability of dynamometers to detect incremental progress ensures that clinicians can set realistic rehabilitation goals and maintain motivation for both the patient and care team throughout the recovery process.

Advanced evaluation tools, such as the quantitative motor test (QMT), offer unparalleled sensitivity in detecting subtle muscular weaknesses that conventional assessment scales might miss. Research by Klehmet et al [37] highlights the critical role of such tools in identifying early signs of neuromuscular dysfunction in CIDP. Unlike traditional manual muscle testing or broader clinical scales, which often lack the resolution to capture minor strength deficits, QMT enables the precise quantification of motor function, even at the earliest stages of impairment.

This capacity for early detection is vital in CIDP, where prompt intervention can significantly alter the course of the disease and prevent irreversible damage. By revealing subclinical changes in muscle performance, QMT supports timely diagnosis, facilitates adjustments to therapeutic regimens, and helps clinicians evaluate the effectiveness of treatment strategies with greater accuracy. Moreover, applying such sophisticated assessments provides a more nuanced understanding of disease progression, enabling personalized care and the optimization of rehabilitation protocols to address specific patient needs. As a result, advanced motor testing is vital in the toolkit for managing complex neuromuscular conditions like CIDP.

Although dynamometer-based evaluations offer critical insights into muscle strength and functional status, they have limitations. One key challenge lies in the nonspecific nature of specific clinical metrics derived from dynamometry, which can complicate the interpretation of results in complex conditions like CIDP. For instance, variations in patient effort, technique, or underlying comorbidities may influence measurements, potentially leading to inconsistent findings that do not fully capture the nuances of disease activity or treatment response.

To address these limitations, a comprehensive diagnostic approach is essential. This includes integrating dynamometer data with other diagnostic tools, such as nerve conduction studies, quantitative motor testing, and clinical scales, to build a more holistic picture of a patient's neuromuscular function. Additionally, longitudinal assessments and combining dynamometry with functional evaluations, like gait analysis or hand dexterity tests, can enhance the reliability and applicability of the findings. As highlighted by Allen et al [38], the value of dynamometer assessments is maximized when they are part of a multidimensional diagnostic framework, ensuring that clinical decisions are well-informed and tailored to the individual patient's condition.

Future Research

Future research evaluating grasp function in patients with CIDP using dynamometers should address several key areas to advance understanding and improve patient outcomes. Longitudinal studies are required to establish normative grip strength data for CIDP patients. Additionally, incorporating patient-reported outcomes will enhance the clinical relevance of strength assessments. Developing enhanced dynamometric tools is essential, focusing on creating more sensitive devices capable of detecting subtle changes in grasp function. Sensor technology and wearable device innovations could facilitate continuous monitoring and real-time feedback. Longitudinal studies are needed to examine the progression of grip strength deficits and their relationship to disease trajectory, helping to establish normative data specific to CIDP patients. Combining dynamometric assessments with advanced diagnostic modalities, such as electrophysiological studies and imaging techniques, could provide a more comprehensive understanding of neuromuscular impairments in CIDP.

To enhance consistency and comparability across studies, efforts should be made to standardize testing protocols for grip strength evaluation. Controlled trials exploring the impact of therapeutic interventions, such as immunomodulatory, physical, and occupational therapy, on grip strength over time would help establish dynamometers as a primary outcome measure in CIDP management. Additionally, investigating the correlation between grip strength and broader functional outcomes, including dexterity, daily living activities, and quality of life, could provide a holistic perspective on the impact of grasp function impairments. Incorporating patient-reported outcomes and preferences into research will ensure alignment with the needs and priorities of individuals living with CIDP. By addressing these areas, future studies can deepen understanding, refine assessment methods, and enhance therapeutic strategies, ultimately improving care and quality of life for patients with CIDP.

Conclusion

Evaluating grasp function in patients with CIDP using dynamometers offers a valuable approach to understanding the functional impairments caused by the disease. Standardization of testing protocols and technological advancements will further enhance its application in clinical and research settings. Future studies should explore novel dynamometric techniques to improve sensitivity and functional outcome correlations in CIDP management. This comprehensive review highlights the effectiveness of dynamometers in quantifying grip strength deficits, monitoring disease progression, and assessing the outcomes of therapeutic interventions. By providing objective and reliable measurements, dynamometry is crucial in bridging the gap between clinical assessment and patient-centered care.

The findings emphasize the importance of standardizing testing protocols and integrating dynamometric data with broader diagnostic and functional measures to better understand CIDP's impact. While current tools are practical, future advancements in technology and research will further refine their sensitivity and applicability. Longitudinal studies and

patient-centered approaches will be pivotal in aligning assessment methods with real-world challenges individuals with CIDP face. Ultimately, dynamometry holds significant potential to enhance the evaluation and management of CIDP, contributing to improved quality of life for those affected by this condition.

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Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: PT; methodology: PT, TC, TIS, CS, DT, SS, KT, AB, AM, PZ and DV; validation: PT, TC, TIS, CS and DV; investigation: PT, DT, SS, KT, AB, AM, PZ and DV; resources: PT, DT, AM and DV; data curation: PT, TC and TIS; writing original draft preparation: PT; writing review and editing: PT; visualization: PT; supervision: DV; project administration: PT and DV. All authors have read and agreed to the published version of the manuscript.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Abbreviations

ALS: amyotrophic lateral sclerosis; CIDP: chronic inflammatory demyelinating polyneuropathy; DADS: distal acquired demyelinating symmetric neuropathy; DHI: Duruoz Hand Index; EMG: electromyography; ICCs: intraclass correlation coefficients; IVIG: intravenous immunoglobulin; QMT: quantitative motor test

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