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Multidisciplinary Rehabilitation in Spinal Muscular Atrophy: Focus on physical Therapy Approaches

SPT. Najla Alshehri[1], Miss. Sarah AL Doussari[2], Miss. Layla Majrashi[3], Mrs Norah Alotaibi[4]

[1]Senior Physical Therapist, PSMMC, Riyadh KSA
[2]Senior Physiotherapist, PSMMC, Riyadh KSA
[3]Physiotherapist, PSMMC, Riyadh KSA
[4]Physical Therapist, PSMMC, Riyadh KSA

ABSTRACT

A genetic neuromuscular disorder known as spinal muscular atrophy (SMA) is caused by the degeneration of motor neurons, resulting in muscle weakness and inability to function properly. As a result of the recent advances in disease-modifying therapies, SMA is changing from a fatal disease in early childhood to a chronic disease over the lifetime. Therefore, the need for extensive multidisciplinary rehabilitation is on the rise. This article stresses the importance of coordination between neurologists, physiatrists, physiotherapists, and other allied health professionals primarily in terms of physical therapy. Physiotherapy in SMA today involves activity-based, task-specific, and participation-oriented approaches instead of merely compensation. It aims to preserve mobility and function, prevent secondary complications, and enhance quality of life. Having physiotherapy early on and throughout their life may be most effective to optimize various outcomes, support independence and participation in daily life due to medical progress.

Keywords: Spinal muscular atrophy, multidisciplinary rehabilitation, physical therapy, neuromuscular disorders, quality of life

INTRODUCTION

Spinal muscular atrophy (SMA) is an inherited neuromuscular disease of genetic basis, which causes progressive degeneration of alpha motorneurons of the anterior horn. Its outcome is muscle weakness, hypotonia, and functional impairment [1]. The disorder mainly impacts proximal muscles and has a broad clinical spectrum that extends from severe infantile-onset forms to milder later-onset forms [2]. More efficient disease modulation therapies today can impact the survival and natural history of SMA. In effect, it has turned from a fatal paediatric disorder into a chronic lifelong one [3]. Hence, there is a greater focus on the comprehensive, multidisciplinary rehabilitation of individuals to optimize function, independence and quality of life through the lifespan [4] . Multidisciplinary rehabilitation in SMA denotes the coordinated efforts of neurologists, physiatrists, physical therapist, occupational therapist, respiratory therapist, orthopaedic surgeon, nutritionist, speech & language therapist, psychologist and social workers [5]. This approach recognizes that SMA affects different body systems and that optimal care involves much more than medication [6].

Disease-modifying treatments are given so as to preserve motor-neurons and slow disease rate thus, rehabilitation strategies are required to maximum remaining motor function, prevent secondary complications and help in participation in activities of daily living [7]. Physical therapy plays the quantitative activity having a central role [8]. Since physical therapists are qualified medical professionals, they can assess one's motor function, muscle strength, joint range of motion, posture, balance and endurance to come up with an individual intervention plan based on the severity of the disease, age and functional status [9]. The SMA aim to maintain and enhance mobility, delay contractures and deformities, enhance postural control, aid breathing and promote safe and efficient movement strategies [10].

It is essential that our physical therapy interventions be flexible and adaptable as the disease progresses, as the child grows, and as new medical treatment options arise [11]. It is clear that SMA physical therapy techniques have developed significantly. Traditionally, therapy focused on compensation and prevention in the context of progressive weakness [12]. As survival and motor outcomes have improved, modern physical therapy has focused on activity-based interventions, task-specific training, and participation-oriented goal [13]. Therapeutic interventions may include range-of-motion exercises, as well as strengthening (within safe limits), postural and balance training, gait and mobility training, respiratory exercises, and the use of devices and orthoses [14]. Emerging strategies including aquatic therapy, supported standing, and technology-assisted rehabilitation further extend the therapeutic options available to SMA patients [15].

Physical therapy must be initiated early as musculoskeletal adaptations such as joint contractures or scoliosis, and decreased bone density might develop early and have long repercussions [16]. All ages benefit from ongoing physiotherapy to stay functional, decrease pain and fatigue, and support psychosocial well-being. Plus, physical therapists help patients and caregivers learn self-management and transition across care settings and life stages effectively [17]. To conclude, multidisciplinary rehabilitation has become an essential component of holistic care, with recent changes in SMA clinical practice. The use of physical therapy is a key component of this approach. This therapy is essential for translating medical intervention into an actual functional gain, facilitating participation and enhancing the quality of life for individuals with SMA.

Review

Spinal muscular atrophy is a type of genetic neuromuscular disorder. SMA causes progressive weakness of muscles and functional decline [18]. This is due to lower motor neuron degeneration. Forward-looking research strategies and clinical trials are required to evaluate the efficacy of these therapies in different patient populations [19]. As a result, SMA care is optimized through comprehensive multidisciplinary rehabilitation designed to promote functional independence, prevent further complications, and improve quality of life [20].

Role of Multidisciplinary Care in SMA

Multisystem involvement of SMA needs input of the team that includes neurologists, physiatrists, physiotherapists, occupational therapists, respiratory therapists, orthopaedic, nutritionists, psychologists [21]. This collaborative approach guarantees that all levels of healthcare are included for the wellbeing of the child. Effective multi-disciplinary rehabilitation provides continuity of care throughout the lifespan, aligns goals and plans around individuals more effectively [22].

Table 1: Multidisciplinary team roles ensuring comprehensive, coordinated care in spinal muscular atrophy

Discipline	Primary Role in SMA Care
Neurologist	Diagnosis, disease classification, monitoring disease progression, and initiation of disease-modifying therapies
Physiatrist (Rehabilitation Physician)	Coordination of rehabilitation care, functional assessment, goal setting, and long-term management planning
Physiotherapist	Preservation of mobility, prevention of contractures, postural management, respiratory exercises, and functional training
Occupational Therapist	Enhancement of independence in daily activities, upper limb function, adaptive strategies, and assistive device training
Respiratory Therapist	Assessment and management of respiratory function, airway clearance techniques, and ventilatory support
Orthopaedic Specialist	Prevention and management of musculoskeletal deformities such as scoliosis, contractures, and hip instability
Nutritionist	Optimization of nutritional status, growth monitoring, and management of feeding-related issues
Psychologist	Psychological support, coping strategies, behavioral interventions, and family counseling

Central Role of Physical Therapy.

Physical therapy is the pillar of SMA rehabilitation and crucial to preserving and maximizing motor function. Physical therapists evaluate various factors like muscle strength and endurance, which assist in creating personal intervention programs [23]. The goal of therapy is to maintain mobility, prevent distortions, target postural hyperactivity and promote independence in daily activities. The severity of the disease, functionality, age-contributing factors, and reaction to medicine influence physiotherapy interventions [24].

Table 2: Physical therapy central to individualized functional management in SMA

Aspect	Description
Core Role	Physical therapy serves as the cornerstone of SMA rehabilitation, focusing on preservation and maximization of motor function
Key Assessments	Evaluation of muscle strength, endurance, and functional abilities to guide individualized intervention programs
Primary Goals	Maintenance of mobility, prevention of musculoskeletal deformities, management of postural abnormalities, and promotion of independence in daily activities
Individualization Factors	Therapy approaches are tailored according to disease severity, functional status, age-related factors, and response to pharmacological treatment

Management of Posture and Range of Motion

The main aim of physiotherapy treatment is to maintain joint mobility in non-ambulant persons. Exercises involving passive, active-assisted, and active range of motion help in preventing joint contractures, relieving pain, and maintaining functional positioning [25]. Supported sitting and standing postural management strategies can be effective in limiting the progression of scoliosis, hip instability and chest wall deformity. The therapies also improve respiratory mechanics and comfort [26].

Table 3: Postural and mobility management prevents deformities and improves comfort

Component	Therapeutic Approach	Purpose / Benefits
Joint Mobility	Passive, active-assisted, and active range-of-motion exercises	Prevention of joint contractures, pain relief, and maintenance of functional positioning
Target Population	Primarily non-ambulant individuals	Preservation of musculoskeletal flexibility and comfort
Postural Management	Supported sitting and standing strategies	Limitation of scoliosis progression, hip instability, and chest wall deformities
Secondary Benefits	Postural alignment and positioning	Improvement in respiratory mechanics and overall comfort

Stamina training, postural and strength training, daily life exercise training.

As evidence mounts to demonstrate that the exercise can be done safely when it is done in a proper way and dosage, SMA rehabilitation is now often including strengthening and endurancetraining [27]. Low- to moderate-intensity strengthening, task-specific functional training, and aerobic conditioning targeting muscle efficiency and functional performance as well as the minimisation of fatigue. Activities like gait training, transitional movements, cycling and aquatic therapy are adjusted according to the individual's tolerance and functional goals [28].

Table 4: Exercise training enhances strength, endurance, posture, and daily function

Training Component	Intervention Type	Purpose / Expected Outcomes
Endurance (Stamina) Training	Aerobic conditioning (e.g., cycling, aquatic therapy)	Improvement in cardiovascular fitness, muscle efficiency, and activity tolerance with reduced fatigue
Strength Training	Low- to moderate-intensity strengthening exercises	Maintenance or improvement of muscle strength while minimizing overuse and fatigue
Postural Training	Postural control and stabilization exercises	Enhancement of alignment, balance, and functional stability during activities
Functional / Daily Life Training	Task-specific exercises (gait training, transitional movements)	Optimization of functional performance and independence in daily activities
Individualization Factors	Adjustment of intensity, duration, and activity type	Tailoring based on individual tolerance, disease severity, and functional goals

Breathing Physical Therapy.

Respiratory muscle weakness contributes majorly to morbidity in SMA. According to the literature, physical therapy interventions to improve respiratory function include breathing exercises, assisted coughing, exercises to improve chest mobility, and coordination with NNEB [29]. Airway clearance is facilitated, as is protection from respiratory complications and improved endurance and activity tolerance [30].

Table 5: Respiratory physiotherapy reduces morbidity and improves functional endurance

Aspect	Intervention / Description	Clinical Benefits
Primary Issue	Respiratory muscle weakness	Major contributor to morbidity in SMA
Breathing Exercises	Targeted respiratory exercises	Improvement in respiratory muscle function and breathing efficiency
Assisted Coughing	Manual or device-assisted cough techniques	Enhanced airway clearance and secretion removal
Chest Mobility Exercises	Exercises to improve thoracic expansion and mobility	Improved ventilation and chest wall compliance
Ventilatory Coordination	Coordination with non-invasive ventilation (NNEB)	Optimized respiratory support and reduced respiratory workload
Overall Outcomes	Integrated respiratory physiotherapy	Reduced respiratory complications, improved endurance, and increased activity tolerance

Tools and Technology Use in Rehabilitation.

Using supportive devices and unique technologies make treatments more effective at physical therapy [31]. Orthoses, mobility aids, customized seating systems and supported standing devices can support alignment, participation and reduce energy costs. The use of rehabilitation technologies such as robotics and technology-assisted training could serve as an appropriate adjunct to enhance engagement and functional outcomes [32].

Table 6: Assistive devices and technology enhance function and participation

Category	Tools / Technologies	Purpose / Benefits
Supportive Devices	Orthoses, mobility aids	Maintenance of alignment, facilitation of mobility, and reduction of energy expenditure
Seating and Positioning	Customized seating systems	Improved posture, comfort, and participation in daily activities
Standing Support	Supported standing devices	Promotion of weight-bearing, postural alignment, and functional engagement
Advanced Rehabilitation Technology	Robotics and technology-assisted training	Enhanced patient engagement, facilitation of task-specific practice, and improvement of functional outcomes
Overall Impact	Integrated use of devices and technology	Increased effectiveness of physical therapy interventions and improved participation

Lifespan and Quality-of-Life Considerations.

Throughout the lifespan, the changing needs of a child with SMA must be addressed. The therapist will usually look at the child's developmental skills and include a lot of play and school participation. In adolescent and adults, the focus will move to independence and vocational activities [33]. Making the fatigue manageable and enabling participation in the community is also an important aspect. Patients and caregivers' education must be an integral part of any successful long-term treatment, maintenance, and activity integration [34].

Table 7: Addresses evolving rehabilitation needs and quality-of-life across lifespan.

Life Stage	Rehabilitation Focus	Key Goals and Considerations
Childhood	Developmental skill training, play-based therapy, school participation	Support motor development, encourage learning, and enhance social interaction
Adolescence	Transition-focused rehabilitation	Promote independence, self-management, and preparation for adult roles
Adulthood	Vocational and functional activity training	Support employment, daily independence, and long-term functional maintenance
Across All Stages	Fatigue management and community participation	Enable sustained activity engagement and improve quality of life
Patient and Caregiver Education	Education and training programs	Promote long-term treatment adherence, maintenance strategies, and integration of therapeutic activities into daily life

Implications for Practice

Multidisciplinary rehabilitation is the latest approach in the management of spinal muscular atrophy, with physical therapy being one of the key aspects. Physical therapy is an essential aspect to optimize function and quality of life, which includes both preventive and activity-based interventions as well as respiratory support and assistive technologies. More research are necessary to identify standardized, evidence-based physical therapy protocols that can keep pace with medical treatment and long-term needs [35].

DISCUSSION

As time passes, multidisciplinary rehabilitation has a major role in the management of spinal muscular atrophy (SMA). This review focuses on physical therapy. It is professional opinion that physical therapy has an important potential role in the management of SMA [36]. The present paper demonstrates the impact that disease modifying therapies have had on rehabilitation goals. This impact goes from purely compensatory strategies towards activitybased, function-oriented strategies that will prevent loss of mobility, improve participation and quality of life in the long-term [37]. An important idea emerging from the literature reviewed is that physical therapy should occur in a coordinated multidisciplinary framework. This complexity cannot be tackled by isolated interventions affecting one system alone, whether it is

musculoskeletal, respiratory or psychosocial [38]. The effectiveness of physical therapy can be significantly enhanced when implemented in conjunction with orthopedic management to rectify deformities, respiratory therapy to maintain pulmonary function, and occupational therapy to achieve independence in activities of daily living [39]. As rehabilitation coordination enhances care delivery, rehabilitation goals are kept realistic, individualized and responsive to disease and treatment response. This conversation also reveals a changes to SMA who receive physical therapy treatment. Historically, fears over excess use weakness led to cautious prescriptions. But, more recent evidence supports the safety and benefits of low- to moderate-intensity monitored physical activity [40]. Performing strengthening, endurance training exercise and task-specific functional exercise is gaining acceptance to maintain motor performance and reduce functional decline especially in ambulatory and less severely affected individuals [41].

It is time to change from passive care to more active rehabilitation strategies as long as fatigue and recovery are well-managed [42]. Range-of-motion exercises and postural care - these are essential for all types of SMA, particularly for non-ambulant people [43]. Prevention of joint contractures scoliosis and postural asymmetries is important as these secondary complications may limit function and aggravate respiratory compromise. The supported standing and positioning strategies considered not only address musculoskeletal alignment, but also have the potential for benefits to bone health, circulation and general well-being, suggesting their place within physical therapy [44].Another critical element discussed in this review is respiratory PT. Due to gradual respiratory muscle weakening, early and continued respiratory interventions are vital for reducing morbidity along with preserving endurance in SMA [45]. The physical therapist's role in respiratory care is growing, as the utilization of breathing exercises, assisted cough and ventilatory support strategies increases in the early detection of functional decline [46]. The use of assistive devices and adaptive technologies further enhance rehabilitation effectiveness by improving participation and lowering energy expenditure.

The above discussion emphasizes the need for timely assessment, prescription, and reassessment of orthoses, mobility aids, and seating systems. According to the report, emerging technologies like robotics as well as technology-assisted training show promise, but their efficacy and feasibility require further research in a range of clinical settings [47]. Through all stages of life, physical therapy can enhance not just physical function but psychosocial health and participation. Rehabilitation has a crucial role in enhancing broader quality-of-life outcomes through the facilitation of developmental milestones in children and of independence in adolescents and adults. Education of patients and caregivers emerges as a recurring and vital aspect that fosters adherence, self-management and maintenance of care outside the clinic [48]. To conclude, rehabilitation for SMA came to signify the key contribution of physiotherapy working collaboratively in teams. According to present evidence, an individualized and proactive approach that targets function of the patient is supported, but higher-quality research is needed to determine standardization, optimal dosing of exercise, and long-term outcomes, particularly with modern disease-modifying therapies. Use evidence to practice integrating emerging into clinical will be crucial to maximize the functional potential and quality of life of people.

CONCLUSION

Multidisciplinary rehabilitation has become an essential part of the overall care of spinal muscular atrophy patients with the advent of disease-modifying therapies. According to this review, physical therapy is necessary to realize the functional gains from advances in medicine. Individualized interventions that focus on preserving mobility, postural control, respiratory support and functional participation are used to manage primary impairments and secondary complications of SMA through physical therapy. The involvement of various disciplines in the healthcare sector makes rehabilitation strategies more effective across the lifespan. As professional experience and proof of principle have built, there is still a need to develop standardized guidelines and high quality studies for active and function-oriented treatment in physiotherapy. The advancement of rehabilitation in conjunction with modern medical treatment will contribute to improvements in long-term function, independence and quality of life of patients with spinal muscular atrophy.

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