



Case Report

Physiotherapy rehabilitation program augmented with virtual reality exergame in myotonic dystrophy: Case report

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ABSTRACT

We present a case report of a 13-year-old girl diagnosed with Myotonic Dystrophy (MD), a neuromuscular disease characterized by symptoms such as muscle weakness, fatigue, pain, and functional limitations. Over a six-month period, she underwent a combined intervention of virtual reality (VR) and physiotherapy rehabilitation program (PTR). Following the intervention, significant improvements were observed in various metrics: the discrepancy between sides of the center of gravity decreased by 8.6%, and stability increased by 4%. The integration of PTR with VR gaming consoles proved beneficial for child with MD, providing both therapeutic benefits and enjoyment. These findings underscore the potential of utilizing gaming consoles to enhance motivation and engagement in rehabilitation for pediatric MD patients. Moreover, our results contribute to the understanding of central movement dysfunction in MD and advocate for personalized treatment strategies based on neurophysiological motor patterns, emphasizing the importance of adhering to recommended protocols.

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1. Introduction

Myotonic Dystrophy (MD) is a slowly progressive neuromuscular disorder characterized by myotonia. Symptoms of MD include distal-axial muscle weakness, gait abnormalities, and balance impairments. Individuals with MD often express concerns about their ability to perform daily living activities due to the disease's progression.¹ Moreover, they are advised to limit physical exertion, leaving the efficacy of strength or aerobic exercise training in muscle diseases uncertain.²

Virtual reality (VR)-based exergaming has emerged as a preferred approach for long-term rehabilitation due to its sustainability and motivational benefits.^{3,4} In this report, we present the effects of a six-month intervention involving VR games combined with a physiotherapy rehabilitation

program (PTR) in a case of MD.

2. Case Presentation

A 13-year-old girl diagnosed with MD presented to the physiotherapy rehabilitation department with primary complaints of numbness, fatigue, and a slowing of her movements. She specifically reported fatigue in her feet, worsening ability to sit and stand weakness in her flexor muscles, particularly in the distal group, and poor control over her extensors. Additionally, she exhibited weakness in movement initiation, stiffness in hand opening, difficulty standing, and limited knee extension. She reported experiencing falls approximately once a week, often resulting in a prone position, mostly occurring outside her home.

Anthropometric measurements, shortness tests, and posture analysis of the case are detailed in Table 1. Balance

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Table 1: The anthropometric measurements, shortness tests, and posture analysis of a case

		Right	Left	
Anthropometric measurement of Spine*	Spina iliaca anterior superior-medial malleol	73	73	
	Spina iliaca anterior superior-tuberositas tibia	43	43	
	Tuberositas tibia-medial malleol	30	30	
	Spina iliaca anterior superior-umblicus	15	15	
	Umblicus-medial malleol	81	81	
	Umblicus-tuberositas tibia	55	55	
	Acromion-earlobe	13.5	13.5	
	Acromion-place of sitting	47	48	
	Spina iliaca posterior superior-place of sitting	13.5	13.5	
	Lower angle of the scapula-spine	10.5	10	
	Lower angle of the scapula-place of sitting	33.5	31.5	
	Hip flexors	1	4	
	Hamstrings	+	+	
	Quadriceps femoris	-	-	
Shortness tests	Tensor fascia latae	-	-	
	Gastrocnemius	+	+	
	Lumbal extensor	+	+	
	Pectorals	-	-	
	Inversion	-	-	
	Eversion	+	+	
	Feet	Hallux valgus	-	-
		Pes planus	0.5 cm	1 cm
		Pes cavus	-	-
		Crop	-	-
Genu recurvatum		-	-	
Knee	Flexion	-	-	
	Tibial torsion	-	-	
	Genu varum	-	-	
	Genu valgum	-	-	
Posture Analysis	Popliteal line inequality	42.5	43	
	Pelvis	Anterior pelvic tilt		+
		Posterior pelvic tilt		-
	Hip	Height difference	74.5	75
		Gluteal line level	67	66
	Columna vertebralis	Lordosis		+
Kyphosis			-	
Scoliosis			Left thoracic C	
Shoulder	Chest deformity		-	
	Protraction		+	
	Retraction		-	
	Rounded		+	
	Height difference	120	120	
Head	Anterior tilt	+		
	Posterior tilt	-		
	Lateral flexion	-	-	
	Rotation	-	-	

Table 2: The Results of Nerve Conduction and EMG (needle) Tests for Case

	Rec. Site	Latency (ms)	Peak Ampl (μV)	Distance (cm)	Velocity (m/s)				
Sensory	R Median digit II (wrist)	II	1.80	6.6	10.5	58.3			
	R Ulnar digit V (wrist)	V	1.65	9.0	9	54.5			
	R Sural Lat Malleolus Calf	Lat Malleolus	2.50	11.2	14	56.0			
	L Sural Lat Malleolus 1	Lat Malleolus	2.20	14.8	14	63.6			
	R Sup Peroneal Foot Lateral Leg	Foot	2.10	13.5	11	52.4			
	L Sup Peroneal Foot Lateral Leg	Foot	2.40	12.8	12	50.0			
	R Median APB	Wrist	2.75	10.9	22	66.7			
		Elbow	6.05	10.7					
	R Ulnar ADM	Wrist	2.05	11.6	19	70.4			
B.Elbow		4.75	11.2						
A.Elbow		6.05	10.8						
Motor	R Common Peroneal EDB	Ankle	4.00	4.6	30	56.1			
		Knee	9.35	3.4					
	L Common Peroneal EDB	Ankle	3.15	10.8					
		Fib head	7.70	9.9					
	R Tibial AH	Ankle	2.95	10.4					
		Knee	10.10	10.4					
	L Tibial AH	Ankle	2.45	9.1					
	Knee	8.60	8.6						
Muscle	IA	Fib	PSW	Fasc	H.F.	Amp.	MUAP	Dur.	Recruitment Pattern
	L Tibialis anterior	None	None	None	None				
	R Tibialis anterior	None	None	None	2+				
	R Gastrocnemius (Med)	None	None	None	2+				
	R Vastus Lateralis	None	None	None	2+				
	R First D Interosseus	None	None	None	3+				
	R Extensor Digitorum Communis	None	None	None	3+				
	R Biceps	None	None	None	3+				

EMG=electromyography, L=left, R=right, N=no activity

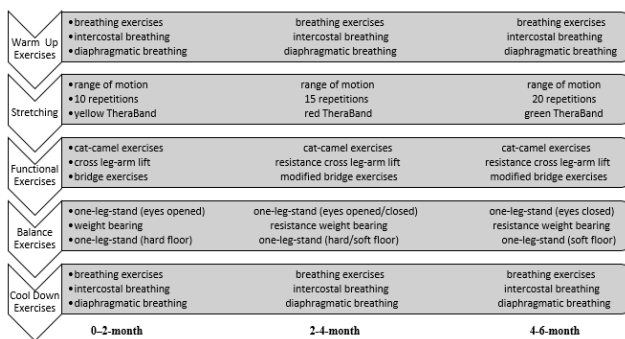


Figure 1: The conventional physiotherapy rehabilitation program

assessments were conducted using Nintendo-Wii-Fit-Plus® (NWFP), which measured body test values including center of gravity (COG), stability, and fit age. During sessions, activities such as "Free Jogging" and "Step" from NWFP were selected, and game scores were recorded.

The NWFP body test revealed a return of COG to the center of equilibrium, while the one-leg standing test on the right side could not be completed. Electromyography results (Table 2) showed stimulation of peripheral nerves in the right upper and bilateral lower extremities. Notably, significant myotonic discharges were observed at rest, particularly prominent in the distal muscles of the upper extremities. These findings consistently indicated the presence of diffuse myotonic discharges in the distal limb muscles.

Table 3: The Results of Intervention on Fatigue, Muscle Strength Test, and Nintendo-Wii-Fit-Plus® (Body Test, Game Scores)

Muscle	Before intervention		After intervention	
	Right	Left	Right	Left
Trunk	Back extensors	4	4	4
	Neck extensors	5	5	5
	Neck flexors	3	4	4
	Rectus abdominus	5	5	5
Hip	Oblic abdominals	5	5	5
	Flexors	4	4	4
	Extensors	3	4	4
	Abductors	4	4	4
	Adductors	3	3	3
	Internal rotators	3	3	3
Knee	Eksternal rotators	3	3	3
	Flexors	4	5	5
	Extensors	5	5	5
Shoulder	Internal rotators	5	4	5
	Eksternal rotators	5	4	5
Arm	Extensors	3	3	4
	Supinator	5	5	5
	Pronator	5	5	5
Wrist	Flexors	5	5	5
	Extensors	5	5	5
Isolated Muscles	Tibialis anterior	5	5	5
	Gastrocnemius	4	4	5
	Foot inverter	5	4	5
	Tibialis posterior	5	5	5
	Serratus anterior	5	5	5
	Trapezius top piece	5	5	5
	Trapezius middle piece	5	5	5
	Trapezius lower piece	5	5	5
	Rhomboideus	5	5	5
	Deltoideus anterior piece	4	4	4
	Deltoideus middle piece	5	4	5
	Deltoideus posterior piece	4	4	5
	Biceps brachii	5	5	5
	Triceps brachii	5	5	5
Fatigue	Visual Analog Scale (VAS)	8	6	
	Center of gravity-COG (%)	45.6	54.4	49.9
Nintendo Wii Fit Plus®	Body Test	Differences of COG (%)	8.8	0.2
		Stability (%)	30	34
		Fit age	31	30
	Game Scores	Free jogging (meter)	3238	3779
		Step (point)	60	106

The case attended the sessions twice per week, each session lasting 45 minutes, over a period of six months. The conventional PTR program (see Figure 1) commenced with warm-up exercises. Virtual reality game exercises were administered using the NWFP game console system. Two aerobic exercises, 'Free Jogging' and 'Step,' were chosen for the intervention. Free jogging entailed a 10-minute session scored based on the distance covered, while Step involved stepping on and off the balance board in sync with on-screen prompts.

Following the intervention, improvements were observed in various parameters. According to the body test, the discrepancy between sides of the COG decreased by 8.6%, stability increased by 4%, and the fit age decreased by one year. The outcomes of the intervention on fatigue, muscle strength, NWFP body test results, and game scores are detailed in Table 3. Notably, the NWFP COG decreased from 8.8% to 0.2%, stability increased from 30% to 34%, and the gap between chronological age and fit age reduced from 18 to 17 years. Game scores also exhibited improvement, with initial scores (Free Jogging= 3238, Step= 60) increasing to final session scores (Free Jogging= 3779, Step= 106).

3. Discussion

This study examines the effectiveness of a PTR program in a case of MD, wherein conventional PTR is augmented with VR-based exergaming. Early evaluation of such cases is crucial for initiating timely interventions, essentially constituting preventive rehabilitation efforts. Fatigue emerges as a significant limiting factor in evaluations, guiding evaluators' focus. Despite MD being classified as a neuromuscular disease, there is a lack of specific protocols in the literature, prompting researchers to explore this field further.⁵

Neuromuscular diseases pose progressive challenges in management, necessitating specialized approaches. Voet et al., in their review, suggest that rehabilitation research encompassing various muscle disorders should present findings separately. They recommend considering participants' pre-training activity levels (sedentary vs. active) and specify intervention parameters such as exercise types, intensity, progression rate, frequency, session duration, muscle groups targeted, and supervision. Moreover, they advocate for interventions lasting at least six weeks to yield meaningful results².

Few studies have investigated interventions for MD, and those that exist often lack robust diagnostic verification of trial participants. Additionally, some trials did not employ intention-to-treat analysis, partly due to matched-pair designs, resulting in significant methodological limitations and an overall unclear risk of bias. However, certain case reports have demonstrated promising outcomes. For instance, one study found that various types of exercise

programs led to improvements in both static and dynamic balance. Another case report by Maresca et al. explored the use of VR for cognitive and behavioral rehabilitation in eleven patients with MD Type-1. They advocated for integrating cognitive rehabilitation into the treatment framework to potentially enhance cognitive and behavioral functions and address neuropsychological symptoms in patients with MD Type-1.⁶

The rehabilitation mechanism remains inadequately elucidated. Neuroplasticity appears to play a central role, particularly in relation to delayed central motor conduction time and abnormal sensory-motor plasticity, with no discernible alteration of cortical excitability.⁷ Future research is warranted to elucidate effective PTR strategies. Lagrue et al. reported that musculoskeletal impairment in 314 children was mild.⁸ Additionally, Naro et al. proposed that gait impairment in MD patients might stem from muscle network deterioration, suggesting it could be a primary trait rather than a consequence of muscle degeneration.⁹ This insight is valuable for tailoring rehabilitative strategies for MD patients, emphasizing the need to address not only muscle weakness but also the muscle connectivity underlying gait function. Although this study primarily involves adults, similar mechanisms should be considered. Understanding these intricacies is crucial for optimizing rehabilitation outcomes. Longitudinal exercise programs are essential for addressing physical impairments and restoring postural stability. Future research should focus on developing protocols that maximize clinical benefits.

4. Conclusion

In conclusion, our case report highlights the potential benefits of integrating virtual reality (VR) gaming consoles into physiotherapy rehabilitation programs (PTR) for pediatric patients diagnosed with Myotonic Dystrophy (MD). Over a six-month period, the combined intervention led to significant improvements in various metrics, including reductions in the discrepancy between sides of the center of gravity and increases in stability. These findings underscore the therapeutic potential of VR-based exergaming in enhancing motivation and engagement in rehabilitation while addressing neuromuscular symptoms associated with MD. However, it is essential to note that further well-designed studies are needed to confirm the efficacy of this approach and its generalizability to larger patient populations. Additionally, future research should explore personalized treatment strategies based on neurophysiological motor patterns and consider integrating cognitive rehabilitation into the treatment framework to address cognitive and behavioral symptoms associated with MD. Understanding the mechanisms underlying rehabilitation in MD and developing longitudinal exercise protocols tailored to individual patient needs are critical for optimizing clinical outcomes and enhancing the

quality of life for individuals living with this progressive neuromuscular disorder.

5. Source of Funding

None.


6. Conflict of Interest


None.

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