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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.



## 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 |
| Shortness tests | | Hip flexors | 1 | 4 |
| | | Hamstrings | + | + |
| | | Quadriceps femoris | - | - |
| | | Tensor fascia latae | - | - |
| | | Gastrocnemius | + | + |
| | | Lumbal extensor | + | + |
| | | Pectorals | - | - |
| Posture Analysis | Feet | Inversion | - | - |
| | | Eversion | + | + |
| | | Hallux valgus | - | - |
| | | Pes planus | 0.5 cm | 1 cm |
| | | Pes cavus | - | - |
| | | Crop | - | - |
| | Knee | Genu recurvatum | - | - |
| | | Flexion | - | - |
| | | Tibial torsion | - | - |
| | | Genu varum | - | - |
| | | Genu valgum | - | - |
| | | 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 | |
| | | Chest deformity | - | |
| | Shoulder | 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 ($\mu$V) | 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 |
| Motor | R Median APB | Wrist | 2.75 | 10.9 | | |
| | | Elbow | 6.05 | 10.7 | 22 | 66.7 |
| | R Ulnar ADM | Wrist | 2.05 | 11.6 | | |
| | | B.Elbow | 4.75 | 11.2 | 19 | 70.4 |
| | | A.Elbow | 6.05 | 10.8 | 10 | 76.9 |
| | R Common Peroneal EDB | Ankle | 4.00 | 4.6 | | |
| | | Knee | 9.35 | 3.4 | 30 | 56.1 |
| | L Common Peroneal EDB | Ankle | 3.15 | 10.8 | | |
| | | Fib head | 7.70 | 9.9 | 30 | 65.9 |
| | R Tibial AH | Ankle | 2.95 | 10.4 | | |
| | | Knee | 10.10 | 10.4 | 34 | 47.6 |
| | L Tibial AH | Ankle | 2.45 | 9.1 | | |
| | | Knee | 8.60 | 8.6 | 34 | 55.3 |

| Muscle | Spontaneous | | | | | MUAP | | Recruitment |
|---|---|---|---|---|---|---|---|---|
| | IA | Fib | PSW | Fasc | H.F. | Amp. | Dur. | 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 Interrosseus | | 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

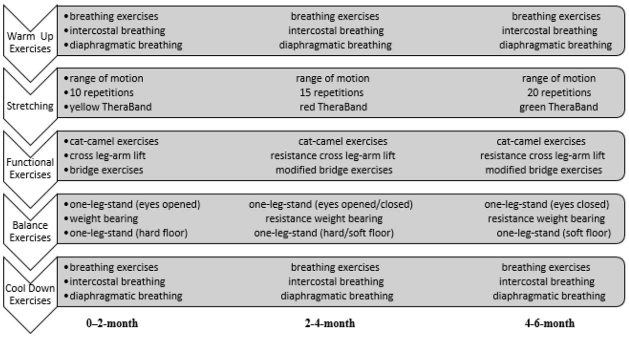


**Figure 1:** The conventional physiotherapy rehabilitation program

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 | |
| | | Neck extensors | 5 | | 5 | |
| | | Neck flexors | 3 | | 4 | |
| | | Rectus abdominus | 5 | | 5 | |
| | | Oblic abdominals | 5 | 5 | 5 | 5 |
| Hip | | Flexors | 4 | 4 | 4 | 4 |
| | | Extensors | 3 | 4 | 4 | 4 |
| | | Abductors | 4 | 4 | 4 | 4 |
| | | Adductors | 3 | 3 | 3 | 3 |
| | | Internal rotators | 3 | 3 | 3 | 3 |
| | | Eksternal rotators | 3 | 3 | 3 | 3 |
| Knee | | Flexors | 4 | 5 | 5 | 5 |
| | | Extensors | 5 | 5 | 5 | 5 |
| Shoulder | | Internal rotators | 5 | 4 | 5 | 5 |
| | | Eksternal rotators | 5 | 4 | 5 | 5 |
| | | Extensors | 3 | 3 | 4 | 4 |
| Arm | | Supinator | 5 | 5 | 5 | 5 |
| | | Pronator | 5 | 5 | 5 | 5 |
| Wrist | | Flexors | 5 | 5 | 5 | 5 |
| | | Extensors | 5 | 5 | 5 | 5 |
| Isolated Muscles | | Tibialis anterior | 5 | 5 | 5 | 5 |
| | | Gastrocnemius | 4 | 4 | 5 | 5 |
| | | Foot inventer | 5 | 4 | 5 | 5 |
| | | Tibialis posterior | 5 | 5 | 5 | 5 |
| | | Serratus anterior | 5 | 5 | 5 | 5 |
| | | Trapezius top piece | 5 | 5 | 5 | 5 |
| | | Trapezius middle piece | 5 | 5 | 5 | 5 |
| | | Trapezius lower piece | 5 | 5 | 5 | 5 |
| | | Rhomboideus | 5 | 5 | 5 | 5 |
| | | Deltoideus anterior piece | 4 | 4 | 4 | 4 |
| | | Deltoideus middle piece | 5 | 4 | 5 | 5 |
| | | Deltoideus posterior piece | 4 | 4 | 5 | 5 |
| | | Biceps brachii | 5 | 5 | 5 | 5 |
| | | Triceps brachii | 5 | 5 | 5 | 5 |
| Fatigue | | Visual Analog Scale (VAS) | 8 | | 6 | |
| Nintendo Wii Fit Plus® | Body Test | Center of gravity-COG (%) | 45.6 | 54.4 | 49.9 | 50.1 |
| | | 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 results[2].

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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