INTRODUCTION

• Cerebral palsy (CP) is the most common cause of developmental physical disability in childhood. It is characterized by abnormal muscle tone causing deficits in posture and movement control.
• These deficits compromise functional mobility, thus therapy is essential for children with CP.
• The goal of this investigation was to examine motor learning in children with CP based on low-dimension remapping of classical ballet postures performed by age-matched typically developing (TD) children using a VR environment.

METHODS

• All methods were approved by the IRB of Northwestern University. Eight typically developing (TD) and 14 children with GMFCS I-II, ages 8 to 12, participated in the study.
• The children with CP attended three training sessions per week for two weeks. Each session lasted 15-20 min including two tasks; Task 1 for upper limbs and Task 2 for upper and lower limbs, each with a unique set of three postures to learn.
• Target postures were chosen from dance movements to counter the abnormal motor patterns of children with CP.
• Eight body landmarks were tracked on each child using an optical motion tracking system (Natural Point, OptiTrack, OR).
• The body landmarks generated a signal space of dimension \( n = 24 \). The target postures were created by calculating the principal components (PCs) of the signal space of the TD group; extracting the coordinates of the target postures; displaying them as target spheres; and projecting the coordinates of body landmarks of the training child into the space of the first two PCs in real time in the VR space.

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\begin{bmatrix}
\sum_{i} a_{i} x_{i} + b_{0}
\end{bmatrix}
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• Number of exact matches, trajectory smoothness using the spectral arc length metric based on Fourier magnitude spectrum of the movement speed were used to assess motor learning outcomes.

RESULTS

• Children with spastic and dystonic CP demonstrated motor learning by increasing the total number of matches with the target postures from the first to the last training session in both tasks. Two-tailed t-tests showed a significant increase in the number of exact matches (alpha=0.05) for the spastic group (p=0.0019) and the dystonic group (p=0.0433) in Task 1. Additionally the children with spastic CP had a significant increase already evident by training session 5 (p=0.0142). In Task 2 significant improvement was only seen in the spastic group (p=0.0015).
• Analysis of the trajectory smoothness was computed using the spectral arc length metric based on the Fourier magnitude spectrum of the movement speed. In Task 1, the group of children with spastic CP demonstrated significantly increased smoothness of trajectory in 7 of the 8 trackables (alpha=0.05). In Task 2 they demonstrated significant improvement in one trackable representing the right hand. The group of children with dystonic CP demonstrated no significant improvement in either task. Additionally, they actually had less trajectory smoothness by the last training session in Task 2.

CONCLUSIONS

• The results demonstrated that children with CP do learn new representations of space by exploration of map of principal components of body motions with continuous feedback.
• Motor learning of reduced dimension seems to be viable for clinical classification of spasticity and dystonia.
• Motor learning of reduced dimensions seems to be an effective therapeutic intervention for trajectory smoothness in children with primarily spastic CP presentations.

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