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The role of the cerebellum in rock climbing

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Cerebellar ataxia; Motor control; Rock climbing; Movement disorders

Dear Editor,

Rock climbing is a highly specialized sport, which requires the complex integration of balance and posture in addition to muscle strength in all four limbs [1]. Postural adjustment to maintain static equilibrium between the horizontal and vertical forces is essential in rock climbing [2]. The complicated coordination between the sensory and motor system in rock climbing is thought to be the function of the cerebellum, as cerebellar dysfunction leads to incoordination of motor performance and impairment of acquiring new motor skills and sequences [3]. We report a case of severe cerebellar ataxia with relatively good rock climbing performance that might challenge the traditional concept of the role of the cerebellum in motor control.

1. Case report

A 46-year-old man has a 20-year history of cerebellar ataxia, manifested as severe dysarthria, hand dysmetria, truncal unsteadiness, incoordination of upper and lower extremities, and frequent falling while walking. He needs two-point sticks to walk (Video 1). He does not have any parkinsonian or dystonic features. Extensive genetic testing, including whole exome sequencing, Niemann-Pick disease, spinocerebellar ataxia 1, 2, 3, 6, 7, 8 and Friedreich's ataxia did not reveal any significant abnormalities. Auto-antibodies associated with cerebellar ataxia were negative. His magnetic resonance imaging shows marked cerebellar atrophy (Fig. 1), and his muscle biopsy showed mitochondrial cytopathy, consistent with mitochondrial disorders. He has a total score of 31 on the scale for the

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Author contribution

Dr. Chi-Ying Lin: study concept, acquisition of data, data interpretation, and draft of the manuscript. Dr. Sheng-Han Kuo: study concept, acquisition of data, data interpretation, critical revision of the manuscript for important intellectual content, and study supervision.

Disclosure

The authors report no conflicts of interest.

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assessment and rating of ataxia (SARA, ranged 0–40 with the higher number representing more severe ataxia) with 6 on the gait subscale (ranged 0–8). He also has remarkable upper and lower appendicular ataxia, with 2 on the bilateral finger chase (dysmetria under/overshooting target < 15 cm), 2 on the bilateral nose-finger test (tremor with an amplitude < 5 cm), 2 on the bilateral fast alternating hand movements (clearly irregular, single movements difficult to distinguish or relevant interruptions < 10 s), and 3 on the bilateral heel-shin slide (severely abnormal, goes off shin 4 or more times during 3 cycles). Despite his great difficulty in walking, he still could perform rock climbing relatively well (Video 1). In fact, he won the gold medal of Climbing Adaptive National Championships in the United States.

2. Discussion

The cerebellum has been considered critical for motor learning and motor control. Interestingly, this present case has a long-standing, severe cerebellar ataxia without evidence of other basal ganglia or motor system dysfunction, and he could perform rock climbing relatively well. Interestingly, the cerebellar function has been linked to rock climbing as rock climbing requires limb coordination and professional rock climbers also can have increased volume of the cerebellum vermis [5]. Our case challenges this view of the cerebellum in rock climbing. Alternatively, The compensatory effect from other brain regions, such as the frontal cortex [4], could possibly explain the climbing skills in this subject since the cerebellar dysfunction developed slowly. However, this compensatory mechanism seems to preferentially favor the rock climbing over ambulation. Another plausible explanation for our observation is that locomotion in the horizontal plane and vertical plane might preferentially involve different brain circuitries, which deserve further exploration.

As performing rock climbing requires the use of four limbs on the vertical plane, we further investigated the use of four limbs on the horizontal plane as a comparison by videotaping the patient's crawling (Video 2). We found that the stability of the whole body using four limbs on the horizontal plane (i.e., crawling) is similar to the vertical plane (i.e., climbing), both of which are better than using two limbs on the horizontal plane (i.e., walking). The spared function in both crawling and climbing could be due to the greater stability when using four limbs, which has less requirement for cerebellar-dependent coordination. Future studies might focus on the comparison between our case to non-ataxic individuals with sufficient practice of rock climbing to the same degree, which will provide further insight on the question whether the motor learning in rock climbing is dependent on the cerebellum. Our present observation demonstrates the differential role of the cerebellum in motor control and has a broader implication to our understanding of brain circuits for ambulation and locomotion control.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Fig. 1.

Brain MRI

Axial (A) and sagittal (B) views of T2 FLAIR brain MRI show severe atrophy of the cerebellar vermis and hemispheres.

*MRI: magnetic resonance imaging; FLAIR: fluid attenuated inversion recovery.