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PERSPECTIVE ARTICLE

Recommendations on the management and prevention of spinal cord injury in children following backbend dance

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Abstract

Spinal cord injury (SCI) is a kind of disease that indiscriminately affects all age groups, although the number of SCI cases in children is far lower than that in adults. In this paper, we discuss the appropriate diagnostic methods and prevention methods for SCI caused by repetitive hyperextension movement. Case study reports available in the published literature concerning SCI due to hyperextension movement, which were categorized using the American Spinal Injury Association (ASIA) grades, were gathered. Moreover, the age, gender, lesion length on magnetic resonance image (MRI), time of symptoms appearance, initial spinal cord atrophy region, neurological level of injury, and initial and final ASIA grades were analyzed. A total of 144 cases with SCI after backbend dance were included in our analysis, with some cases with an incubation period ranging between 15 min and 4 h showing no symptoms. Most of the collected cases were young girls of <11 years old. Early MRI showed that the pathological changes had extended toward cephalocaudal regions. In summation, the number of SCI cases, which are disabling for many children, is rapidly accumulating in China. Thus, SCI following repetitive hyperextension movements requires further research.

Keywords: Spinal cord injury; Repetitive hyperextension; Backbend dance; Children; China

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1. Introduction

Spinal cord injury (SCI) is a devastating ailment to the affected children, given that they need to endure the implications and burdens posed by this disorder for a long time from a young age.[1] This ailment is financially burdening for the affected individuals and their families owing to the costly treatment and rehabilitation services, in addition to the need for personal assistance, lost productivity due to disability, and social isolation. Thus, it is conceivable that the lifelong treatment cost of SCI for children is much higher than that for adults.[2,3]

SCI in children is far less common than in adults, accounting for 2 – 5% of all spine traumas.[4] An epidemiological study in the United States of America found that the

incidence of SCI in children is 8 – 13/million annually.[5] To date, much of the management and treatment of pediatric SCI has been extrapolated from the adult literature, given the low incidence of pediatric SCI and the limited number of cases in children.[4]

China has a significant number of SCI cases. However, there is no national or regional SCI registry system in China. As a result, the incidence of SCI in all age groups, especially among children, remains unclear.[6,7] Public education, improved safety features in motor vehicles, and the stricter enforcement of seat belt laws, driving-under-the-influence regulations, protection of minors, and prohibition of child labor may have contributed to a decline in SCI rates among children. In China, the number of SCIs in children caused by backbend movements during dance training is increasing and accounts for 50% of all SCIs in children in the past two decades.[8,9] SCI caused by these movements, which have been left unaddressed and unresearched for a long time, brings a heavy psychological and economic burden to children and their families.

2. Case studies and findings

More than 200 cases of SCI have been reported in China over the past 5 years.[8-11] In this paper, we reviewed the data gathered from six articles, which included 144 Chinese children with SCI that happened after repetitive hyperextension movement (backbend movements) during dance training.[8-10] Other cases of SCI that was not related to repetitive hyperextension movement were excluded.

Almost all of the cases occurred in young girls under 11 years old. The age distribution of this injury ranges from 3 to 11 years old (Figure 1), and 99% of cases were under 10 years old with an average age of 6 ± 2 years. All of them presented hyperacute onset of SCI within the first 4 h after the injury, and many cases showed no symptoms during the first few minutes after injury. However, during the incubation period (15 min to 4 h) from accidental injury in dance training to paraplegia, no interventional approaches or effective treatments were implemented, such as training cessation, immobilization or supine rest, and early medical treatment. However, no obvious fractures or dislocations were found in the imaging examination after the injury. Only magnetic resonance imaging (MRI) showed a longitudinally diffuse intramedullary high-intensity signal and spinal cord edema, while the extent of edema was not consistent with the neurological level of injury (Table 1 and Figure 2). The final follow-up showed poor prognosis in patients with complete SCI (American Spinal Injury Association [ASIA] grade A)[8-10] (Table 2). The final follow-up MRI conducted 1 – 4 months after intervention showed distal spinal cord atrophy (Figure 3). Moreover, the long-term follow-up also revealed that the patients with complete SCI were grappling with serious complications, such as scoliosis, hip dysplasia or dislocation, bedsore, urinary tract infection, lower limb neurogenic fracture, and muscle atrophy.[1,10]

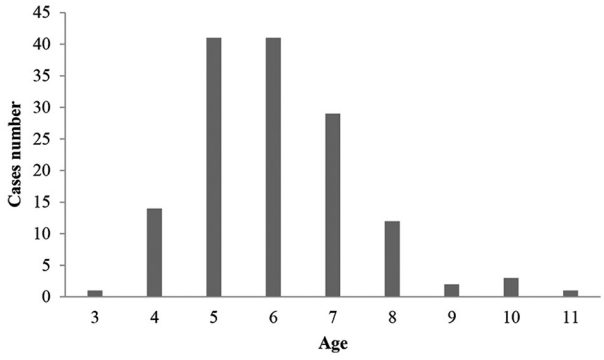


Figure 1. The age distribution of spinal cord injury after hyperextension movement. Data used to derive this figure are taken from reference.[8-10]

3. Practical implications

With the continued enhancement of health consciousness, many children are becoming involved in recreational activities, such as yoga, gymnastics, ballet, cheerleading, acrobatics, pilates, backbends, surfing, and swimming, which often entail a certain degree of risk to continuous spine hyperextension movements. However, SCI resulting from backbend dance remains largely neglected by the public, dance training institutions, as well as sports centers in China.[8-11] Such negligence will not put a halt to the occurrence of SCI due to hyperextension movement.[10] At present, there are no relevant recommendations to prevent SCI occurrence in children during dance training.

According to China's seventh census, there are more than 250 million children aged 0 – 14 in the country, accounting for 17.95% of the total national population.[12] Following a shift to China's fertility policy[13] – replacement of the one-child policy with the three-child policy – expectedly China will usher in a new round of baby boom, which potentially increase the proportion of children population. At the same time, as part of the government's education reform efforts, measures are being taken to reduce the excessive burden of homework and after-school tutoring for primary and middle school students. The policy change and the implementation of new homework burden-lessening measures would spur the increased participation of children in recreational activities,[14] which will inevitably raise the incidence of SCI in this young-age population.

Wang *et al.* hypothesized that the effect of internal organs on the inferior vena cava may lead to impaired blood perfusion, primarily at the T9-T10 level, ultimately resulting in ischemic SCI.[10] At present, magnetic resonance

Table 1. The distribution of intramedullary lesion length with high-intensity signal based on MRI

	Number of vertebral levels with high-intensity signal based on MRI															
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**17**
Complete injury	0	0	1	3	5	5	10	19	15	9	9	13	7	5	4	1
Incomplete injury	4	0	3	0	9	11	18	24	22	10	10	15	0	6	0	0

Notes: Complete injury: ASIA grade A; Incomplete injury: ASIA grades B, C, and D. Data used to derive this table is taken from reference.[8-10]
Abbreviation: MRI: Magnetic resource imaging.

Table 2. ASIA grades during initial and final follow-up

ASIA grades during initial follow-up		ASIA grades during final follow-up and number of cases				
ASIA grade	**Number of cases during initial follow-up**	**A**	**B**	**C**	**D**	**E**
Grade A	104	101	2	1	0	0
Grade B	26	0	11	6	7	2
Grade C	7	0	0	2	4	1
Grade D	7	0	0	0	6	1

Note: Data used to derive this table are taken from reference.[8-10]
Abbreviation: ASIA: American Spinal Injury Association.

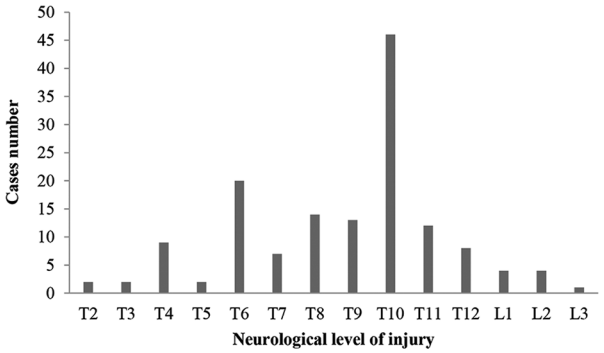


Figure 2. The distribution of neurological level of spinal cord injury. Data used to derive this figure are taken from reference.[8-10]

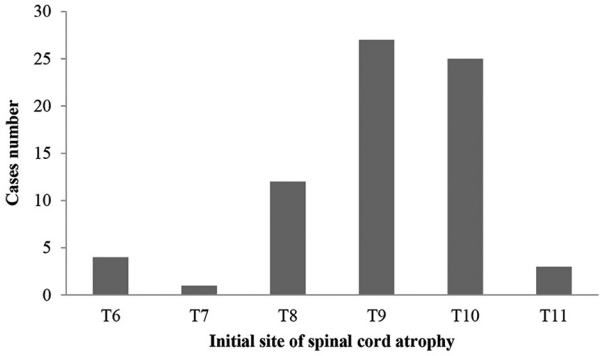


Figure 3. The extent of spinal cord atrophy. Data used to derive this figure are taken from reference.[8-10]

angiography remains the gold-standard technique for confirming and predicting the prognosis of repetitive hyperextension-induced SCI.

After confirming the diagnosis and assessing the severity of the injury, it is crucial to monitor the patient's vital signs. Conservative treatment can yield significant results in stable cases but may not improve the condition in unstable cases. Overall, the prognosis of SCI depends on the severity of the initial injury, the timing and accuracy of diagnosis, and the implementation of appropriate treatment.[15-17] At present, a limited range of therapeutic treatments is available for both adults and children affected by SCI, and the lack of treatment would lead to severe and persistent neurological abnormalities and disabilities that can persist for decades until death.[15-17] Therefore, to expand the variety of SCI treatments for children, further and extensive research is required. Badhiwala *et al.* advocate that "time is the spine," but whether early surgical intervention is necessary for this specific SCI is still unknown.[16] Therefore, preventing SCI during dance training is currently the best feasible strategy.

According to the literature, we propose the following several recommendations on the management and prevention of SCI for children engaging in backbend dance:

1. Children under the age of 10 should refrain from practicing spine hyperextension movements
2. Coaches and parents of children participating in hyperextension activities should be informed that these spine movements may lead to SCI. Furthermore, they should take careful measures to protect the children and prevent accidental injuries during training sessions that involve hyperextension movements
3. At the time of injury, training should be stopped immediately, and children should be immobilized and placed in a supine resting position to prevent injury deterioration and the occurrence of secondary injury. Medical help should be sought immediately if any neurological symptoms appear
4. The potential occurrence of SCI due to backbend dance should be brought to the attention of the general public, guardians, sports institutions, and education departments, as part of the awareness-

raising effort. It is also necessary to issue proper guidelines highlighting the potential hazards of backbend dance and providing recommendations on the effective measures to prevent SCI arising after repetitive hyperextension movement

5. Legislations should be in place to prohibit children under the age of 10 from participating in this type of sport.

4. Conclusion

SCI resulting from backbend dance differs from other types of SCI in terms of the mechanism of injury, symptoms, and imaging abnormalities. Deserves in-depth investigations of this devastating injury are warranted to widen our understanding of its underlying pathogenic mechanisms and pathways as well as to explore effective treatments that can minimize the injury's perennial complications.

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Conflict of interest

The authors declare that they have no competing interests.

Author contributions

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Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

Not applicable.

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