Athletes with Brain Injury
Pathophysiologic and Medical Challenges

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KEYWORDS

• Cerebral palsy • Athlete • Elite • Paralympic • Neuromuscular • Performance • Medical • Injury

KEY POINTS

- Movement dysfunction resulting from brain injury is typically attributed to damage to either the pyramidal (hypertonic type) or extrapyramidal tracts (dyskinetic and mixed types).
- One of the key features of brain injury is altered central efferent output, which has direct effects on neuromuscular function and exercise performance.
- Hypertonia (spasticity), athetosis, ataxia, incoordination, incorrect control of smooth movement, and coactivation are commonly observed in athletes with brain injury.
- Exercise-related medical challenges include ankle and foot deformities, pain, fatigue, musculoskeletal injury, maximal exertion and muscle spasms, and degenerative arthritis.
- Non–exercise-related medical challenges include oral health, vision and hearing impairments, higher-than-average comorbidity rates, depression, athletes with severe impairment, and psychological resilience.

INTRODUCTION

Historically, physical activity was not considered an integral component of rehabilitation or general clinical standard care for individuals with brain injury. Early studies investigating optimal rehabilitation programs have been successfully implemented in individuals with brain injury; however, these studies almost exclusively investigated function and quality of life in severely affected, sedentary children.[1–4]

However, the growth of the Paralympic movement has resulted in a concomitant increase in published scientific studies relating to athletes with brain injury. In recent years, several studies have investigated the athletic performance capacity, and associated physiologic parameters, of this group of athletes.[5–10] There is now

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an improved understanding of how these factors interact with the well-established evidence base of medical challenges associated with brain injury.[11] Therefore, the current article presents the most important pathophysiologic and medical challenges facing athletically inclined individuals with brain injury and their managing physicians and highlights the potential benefit of sport for the general brain-injured population.

DEFINITION AND CAUSES OF BRAIN INJURY

Congenital Brain Injury

Congenital brain injury (CBI), often termed cerebral palsy, is a group of permanent nonprogressive movement disorders resulting from static lesions to the immature brain.[12] With an incidence of 2.5 cases per 1000 live births, these brain lesions typically occur during pregnancy, birth, or within the first 3 years of life.[11,13–16]

Acquired Brain Injury

Acquired brain injury is an alteration in brain function that occurs later in life through either nontraumatic or traumatic origins and is not related to congenital impairment or degenerative disease.[17] In the United States, traumatic brain injury has an estimated hospitalization rate of 500,000 cases per year.[11] Traumatic brain injury is most common in men and has the highest incidence in the 15-year to 25-year age group.[11]

Recently, there has been increased interest in the study of concussion, a type of acquired brain injury, within the Para sports arena, including the long-term risk of repeated concussions.[18,19] Although concussion, mild traumatic brain injury (which is evident on computed tomography or MRI) and their sequelae are outside the scope of this article, it is important that this area of research be highlighted.

PATHOPHYSIOLOGIC CHALLENGES OF ATHLETES WITH BRAIN INJURY

Neuromuscular Control of Movement

Typical central nervous system control of movement and posture occurs at 3 levels.[20,21] First, the excitatory impulse from the brain moves from the supplementary motor cortex through the sensorimotor cortex. Second, it moves through the cerebellum, basal ganglia, and brainstem. Third, it is translated into movement patterns by the spinal cord and peripheral motor units. This last level of motor planning is regulated by stretch reflexes within skeletal muscle. Primary neurologic impairment or disturbance of this system results in several distinguishing features, which are addressed later in this article.[22]

Decreased central output

One of the key features of brain injury is altered central efferent output,[23,24] which has a direct effect on neuromuscular function and exercise performance. Research has shown that voluntary muscle activation is up to 49% lower in children with CBI, compared with able-bodied controls[25,26]; that is, the number of motor units available for activation in children with CBI is the same as for able-bodied controls, but the motor units remain inactivated unless maximally stimulated at the level of the muscle.[23,24] This finding indicates that skeletal muscle is under-recruited because of central inhibition.[25] Central inhibition also results in muscle atrophy and weakness, as well as loss of coherent movement in affected anatomic areas associated with the location of the brain injury.[27]

Movement dysfunction associated with brain injury

Movement dysfunction as a result of brain injury is typically attributed to damage to either the pyramidal or extrapyramidal tracts.[21]