Etiology

Cerebral palsy (CP) is "a group of permanent disorders of movement and posture causing activity limitation that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain."[1] While CP is non-progressive, this neuromuscular disorder can cause progressive motor impairments and posture disorders throughout the lifespan.[2–4] Cerebral palsy is extremely heterogeneous in its clinical presentation depending on the site of the brain lesion and severity of the impairments.[4] The Gross Motor Function Classification System (GMFCS) is a five-level system commonly used to classify persons with CP.[5] The classification system is based on self-initiated movement with an emphasis on sitting, transfers, and mobility.[5] Distinction between the levels are determined by functional limitations, the need for hand-held or wheeled mobility devices, and quality of movement.[5] The general headings described by Palisano et al[5] are as follows: Level I: Walks without Limitations; Level II: Walks with Limitations; Level III: Walks Using a Hand-Held Mobility Device; Level lV: Self-Mobility with Limitations, May Use Powered Mobility; Level V: Transported in a Manual Wheelchair.

Cerebral palsy affects between 2 and 3.5 per 1000 live births world-wide[4] and is considered to be the most common disabling condition in children.[6] Presently, the prevalence of CP in the United States (US) is estimated to be between 3 and 4 per every 1000 school-aged children.[1] The risk factors for CP are multifactorial and include, but are not limited to, premature birth, maternal infection, in utero perinatal and neonatal infection, and birth trauma.[4,7] There are an estimated 500,000 adults living with CP in the US.[8] The life expectancy of individuals with CP is similar to that of their typically developing peers and can be influenced by the severity of cognitive, motor, ambulatory, and visual impairment.[4] Life expectancy decreases in proportion to the quantity and severity of an individual's associated impairments.[1,4]

Aging in Cerebral Palsy

Impaired joint development and joint deformity occur early in life in individuals with CP.[2] Due to the effects of aging, increased joint deformity, development of osteoarthritis (OA), pain, and fatigue commonly occur with increased age in this population.[2,4,8] Though not considered a progressive disease, there is evidence to show that individuals aging with CP, do develop secondary conditions at an earlier age than their typically developing peers.[9] Decreased range of motion and cardiovascular endurance, muscle weakness, obesity, osteoporosis, increased muscle tone, spasticity, and impaired vision are common secondary conditions that occur as a result of the primary diagnosis of CP. The above secondary conditions and subsequent impairments are common contributors to fatigue, chronic pain, and decreased function and mobility.[1–3,8,10,11] This "downward spiraling" effect is in part due to the fact that individuals with CP are facing the effects of aging in addition to their disability.[3]

Pain and fatigue are commonly reported among adults with CP.[4,8] Pain has been estimated to occur in 30 to 80% of adults with CP, with an increased prevalence associated with advancing age.[9,12] Pain results from OA, increased spasticity, weakness, falls, spasms, contractures, hip dislocation, and gastric reflux.[4,9,13] Moderate to severe activity limitations have been reported to be associated with pain.[9] Pain and fatigue are interrelated and together lead to decreased function in this population.[9]

Depression often occurs in persons with CP, particularly those with lower gross motor functioning and chronic pain.[4,12,14,15] Jensen and colleagues suggest that at least 42% of adults with CP and chronic pain experience depression.[14] The combination of activity limitations, fatigue, pain, and depression, have been found to limit community integration and the ability to work, dress, grocery shop, perform self-care tasks, and maintain a social life.[4,9] Regardless of the severity, deterioration of skills and possible low-life satisfaction will occur in individuals with CP resulting in decreased quality of life (QOL).[9] In adults with CP, it is imperative to preserve health and mobility to positively influence employment, independence, and both health-related and general QOL.[1] Functional declines and depressive symptoms may be minimized by rehabilitation interventions and aerobic exercise.[4,7,16]

Land Versus Aquatic Interventions

There is a copious amount of evidence regarding effective interventions for children and adolescents with CP, however there is a paucity of evidence related to interventions for adults.[3,17–19] In general, the evidence suggests that interventions should focus on reducing the effects of secondary conditions,[3] while improving functional capacity, QOL, and social participation.[4,7] Interventions such as stretching have been found to reduce joint contact forces,[3,20] while strengthening exercises may provide shock absorption, reduce pain, and improve strength, physical function, and mobility.[8,21]

Interventions used to treat individuals with CP are traditionally land-based, however, in the past decade there has been some evidence supporting aquatic rehabilitation for this popultion.[22,23] One of the main disadvantages of land-based intervention for individuals with CP is the effect that gravity has on joint integrity and movement.[22,23] Due to the effects of gravity, exercise on land leads to greater joint loading and weight bearing requirements than aquatic exercise.[22,23] There is little support for unstable joints or weak muscles on land which can make resistance training difficult, however resistance in the water can be easily tailored to meet the needs of the patient due to the physical properties of water.[22]

Water has unique physical properties that make aquatic exercise ideal for those with neuromuscular disorders such as CP. The property of buoyancy reduces the effects of gravity, decreases weight bearing and joint loading by decreasing body weight, preventing additional breakdown of articular cartilage, and providing assistance for strengthening activities.[3,24,25] Buoyancy also reduces the weight bearing requirements and the amount of trunk control needed for support which is beneficial for individuals with CP. The properties of turbulence and hydrostatic pressure create resistance to movement in the water that helps increase intensity and allow for equal muscle strengthening around a joint.[3,25,26] The hydrostatic pressure helps to reduce swelling and contributes to pain reduction.[26] The warm water temperatures often utilized for aquatic exercise can also decrease pain, ease soft tissue contractures, and relieve muscle spasms and fatigue.[27]

The benefits of aquatic exercise for individuals with CP include improved muscle strength, gait velocity, balance, energy expenditure, endurance, pain, range of motion, and functional mobility.[3,23,28] Aquatic exercise also promotes aerobic conditioning and strengthening while maintaining joint integrity, which is key to preventing and limiting damage to articular cartilage which can cause painful movement.[2,3] Because of buoyancy

and the variable resistance to movement, the aquatic environment allows for safe exercise for individuals with CP.[3]

It is important for adults with CP to take ownership of their health as they age because the effects of aging are compounded by their disability.[9] The development of secondary conditions may lead to decreased function and mobility however, some of these adverse effects could be mitigated through performance of physical activity.[2,3] Life-long physical activity may also reduce an individual's risk of developing metabolic and cardiovascular diseases.[11]

Aquatic exercise can be beneficial as a life-long fitness activity that may help to prevent some of the secondary conditions associated with CP.[3] This is especially important in adulthood when consistent therapeutic intervention is less accessible.[3,21] Evidence suggests that access to healthcare for adults with disabilities is a concern resulting in adults with CP being considered a disparate health population.[8]

A systematic review of aquatic resistive exercise suggests that the combination of aerobic and strength exercise is most beneficial for improving endurance and muscle strength in children with CP.[23] Most of the articles reviewed identified significant improvements for mobility performance in the home and community environments.[23] More recent evidence suggests that performing functional activities in the water with moderate-to-vigorous intensity may improve the gross motor skills and walking endurance of ambulatory children with CP.[18] An aquatic resistive exercise program has also been shown to be effective in improving walking endurance as well as participation and energy expenditure in an ambulatory child with CP.[28] These findings suggest that continued training is required to maintain gains in the components of body function, activity, and participation and thus that even adults with CP would benefit from aquatic exercise.[28]

There is only one study, to date, investigating the effectiveness of aquatic resistive exercise in an adult with CP.[3] After a 10-week intervention consisting of stretching, lower extremity resistive exercises, and water walking, the patient demonstrated significant improvements in strength, balance, energy expenditure, functional mobility, and self-perception.[3] Eleven weeks after cessation of the intervention, this individual continued to show improvements in lower extremity strength and gait velocity suggesting prolonged benefits of aquatic exercise.[3]

Existing evidence supports the use of aquatic resistive exercise for children and adults with CP, however these studies have small sample sizes and poor methodological rigor. The first purpose of this study was to determine the feasibility of administering an aquatic resistive exercise intervention in a community-based setting. The second purpose of this study was to evaluate the effects of an aquatic resistive exercise intervention on select secondary impairments, health-related QOL, economy of movement and physical activity level in a cohort of adults with CP compared to a comparison sample of their peers who did not receive the intervention.

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