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Effectiveness of Alternative Cerebral Palsy Treatments in Pediatrics: Systematic Review

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Author's Note

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Abstract

Cerebral palsy (CP) is a multi-faceted movement disorder that affects the lives of approximately 500,000 children in America and millions across the globe. Traditional treatment involves physical and occupational therapies. The purpose of this systematic review is to identify, describe, and critically appraise the evidence about the effectiveness of alternative therapies including hippotherapy, aquatic therapy, and robotic gait training in children with CP. Researchers have found that these therapies improve gross motor function and balance. This review focuses on determining which age subpopulation would benefit most. A critical appraisal of studies is conducted and followed by recommendations for practice based on the findings, validity, reliability, and applicability of the studies. This systematic review may have implications in the nursing care of children with CP and nurse advocacy for increased availability of alternative treatments. Further, this project is an example of what baccalaureate-prepared nurses do to determine evidence for practice.

Cerebral palsy (CP) is a "group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain" (Hockenberry, 2015, p. 1617). According to the Center of Disease Control Data and Statistics for Cerebral Palsy (2018), an estimated one out of every 323 children has been diagnosed with cerebral palsy. "The Prevalence of Cerebral Palsy" (2018) by the Cerebral Palsy Foundation reveals that every year 10,000 children in the United States are born with this condition: prevalence of children in the United States, under the age 18, with the diagnosis of cerebral palsy is approximately 500,000. With this number of children impacted by this condition, it is important to consider how to effectively improve this population's quality of life. This disorder can have profound effects on operative functions such as cognition, gait, coordination, and behavior. Cerebral palsy can cause additional problems depending on the severity of the disorder. "Cerebral Palsy" by the Mayo Clinic (2016) described that problems include but are not limited to gastroesophageal reflux, epilepsy, intellectual disabilities, speech difficulties, vision and hearing problems and contractures. All of these problems lead to a decreased ability to participate in activities of daily living, causing low endurance, less independence, and less enjoyment (Moraes, Copetti, Angelo, Chiavoloni, & David, 2016). Individuals with CP may also experience malnutrition and develop pressure ulcers because of lack of activity (Mayo Clinic, 2016). It is important for nurses and healthcare providers to be made aware of signs and symptoms of cerebral palsy. There is no cure for this disease, therefore, traditional treatment consists of occupational and physical therapy. The goal of treatment is to increase functioning and performance of everyday tasks and thus improve overall quality of life.

There has been research that suggests therapies, other than traditional physical therapy, are beneficial for children suffering from this disorder (Kwon, Chang, Yi, Lee, Shin, & Kim, 2015). Based on literature searches, three alternative therapies for this population have been identified and studied. These include hippotherapy, aquatic therapy, and robotic gait training (refer to appendix A for Table of Evidence). Hippotherapy uses horseback riding as a rehabilitative treatment to increase coordination and balance in children with cerebral palsy (Champagne, Corriveau, & Dugas, 2017). Aquatic therapy utilizes mechanical and thermal effects of water to improve motor functionality (Lai, et al., 2014). Robotic gait training focuses on improving gait by using mechanical devices to support and increase motor abilities (Bayon et al., 2016). These alternative methods bring a different approach to improve gross motor and balance performance for children with cerebral palsy. Nurses should be aware of the treatment options for children with cerebral palsy so that the most effective and appropriate therapy is utilized. The purpose of this systematic review is to identify, describe, and critically appraise the evidence about the effectiveness of the three alternative therapies in children with cerebral palsy. In addition, the systematic review will determine which age subpopulations of children would benefit the most from each of the alternative treatments. The subpopulations of children follow the national pediatric categories of infant (birth to 1 year), toddler (1 to 3 years), preschool (3 to 6 years), school-age (6 to 12 years), and adolescents (12 to 18 years) (Hockenberry, 2015). This review attempts to answer the following PICOT question: How effective are hippotherapy, aquatic therapy, and robotic gait therapy on gross motor function and balance in four to twenty-four-week studies on the subpopulations of children with cerebral palsy compared to traditional therapy?

Methodology

The approach to answering the question above is through a systematic review. A systematic review is a rigorous and systematic synthesis of research findings about a clinical problem (Schmidt & Brown, 2019). For this systematic review, the therapies reviewed were considered alternative therapies, versus complementary therapies. If the therapies were studied strictly as complementary treatments, it would be difficult to determine if the traditional or complementary treatment was causing the effects. In choosing appropriate research to address this problem and answer the PICOT question, the authors used electronic databases of Academic Search Complete, CINAHL, and MEDLINE. Alternative methods include Google Scholar and National Nursing organizations to retrieve relevant research. The paper utilizes both qualitative and quantitative evidence to develop a conclusion and answer the PICOT question. Key search words included: cerebral palsy, motor control, balance, gait, alternative therapies, traditional therapies, hippotherapy, aquatic therapy, robotic gait training, children, and pediatrics. Inclusion criteria are: published within the last 12 years and samples of children with cerebral palsy under 18 years of age. Due to a limited amount of research and to retrieve a greater amount of research articles, currency of studies was extended to 12 years. All research utilized in this systematic review regarding robotic gait training and hippotherapy are within the last five years. However, three aquatic therapy studies exceed the five year limit with the oldest study dating back to 2007 (Aidar, F. J., Silva, A. J., Reis, V. M., Carneiro, A. L., Vianna, J. M., & Novaes, G. S. 2007). Cerebral palsy is usually diagnosed early in age and interventions should be initiated before individuals reach full development therefore, this systematic review focused on the pediatric population (Kwon et al., 2015). To avoid selection bias, all research was taken into consideration, regardless of outcomes.

After the articles were retrieved from the electronic databases, the quality of the articles was assessed. The quality assessment started with determining the study purpose and research question. Location of the clinical research site, sampling methods, sample size, and length of alternative treatment were determined. Next, designs were reviewed and used to determine the levels of evidence generated by the study. The level of evidence reflects the type of design study and quantifies it into a level one to seven, with lower levels more strongly supporting translation of evidence into practice. The results and conclusions of each study determine the nursing and research implications. Analysis of the results revealed which age groups of children each of the three alternative treatments were most effective at improving gross motor function and balance in children with cerebral palsy. Finally, the limitations of each study were considered. The alternative methods are innovative and therefore studied by few researchers. The newness of the research on the interventions means that many of the researchers only determined the immediate effect of the intervention and not the long terms effects. Many of the studies also have smaller samples or no control group, making it hard to generate higher levels of evidence, generalize findings, and find significant effects due to statistical conclusion validity.

Review of Literature

Traditional therapy

Physical therapy is one of the most commonly used treatment modalities in children with cerebral palsy (Hockenberry, 2015). The major approach to this therapy is to utilize traditional types of exercises such as stretching, passive and active range of motion, and resistance training to maintain muscle strength and endurance (Hockenberry, 2015). Elsio (2017) carried out a study with 16 patients, who underwent treatment at Children's Neurology and Neuro-rehabilitation Treatment and Educational Center in Tbilisi, Georgia. Two groups were evaluated for

effectiveness of physical therapy treatment over five years of treatment, one group starting at age 4 months and another at 12 months. Results show that gross motor function points were increased in the case of every child patient, which highlight the effectiveness of physical exercises at a very early intervention (Elsio, 2017). The study measured positive outcome of physical therapy in percentage each year. Overall, results show a greater percentage of positive gross motor development in the group who received treatment started at 4 months. The average percentage after five years in this group is 41.3% compared to 38.1% which is the average for the group that received treatment starting at 12 months. Additionally, in a retrospective data collection of 75 medical records, Brandao, Oliveira, & Mancini (2014) examined occupational therapy activities most relevant to parents of children with CP between the ages of 3 and 16. Brandao et al. (2014) collected and analyzed data on frequency of therapy and priorities during therapy sessions. GMFCS was used to classify individuals with cerebral palsy into categories of severity with level I being the least severe and level V being the most. Personal care, such as hygiene, feeding, and dressing, were the most frequent priority at all levels of motor severity except Gross Motor Function Classification System (GMFCS) level V (Brandao et al., 2014). Hence, functional mobility activities were not the main focus for the parents of children with cerebral palsy. The only age group in which mobility was the highest priority was in the three to six-year age group (Brando et al., 2014). Collaboration with parents in the therapeutic process was also identified in this study.

Hippotherapy

Hippotherapy definition. Hippotherapy is a form of therapist-assisted physical and occupational therapy that utilizes the interaction with and movement of a horse to develop posture, balance, strength, coordination, endurance, and sensorimotor systems (Park, Rha, Shin,

Kim & Jung, 2014). A full-sized walking horse transfers 110 three-dimensional swinging motions to the rider each minute (Ratan Purohit, Jayprakash Vyas, & Sandeep Sheth, 2015). The impulses are similar to the natural movements of the human pelvis and hips including forward-backward, side-to-side, up-and-down, and rotational movements (Ratan Purohit et al., 2015). Champagne et al. (2017) found that to maintain vertical alignment during the constant movement, riders must constantly utilize trunk muscles. In the majority of the studies about hippotherapy, children rode the horses while therapists walked alongside the horses. Certified trainers lead the horses and one or two trained assistants or volunteers walked on the other side of the animal or were nearby.

Description of studies. Of seven studies about hippotherapy, researchers of four used quasi-experimental designs, level of evidence of 6 (Champagne et al., 2017; Moraes et al., 2016; Mutoh et al., 2017; Ratan et al., 2015). The remaining three studies were randomized controlled trials generating level of evidence of 2 (Angsupaisal et al., 2015; Kwon et al., 2015; Park et al., 2014). The studies were conducted in Brazil (Moraes et al., 2016), Canada (Champagne et al., 2017), India (Ratan et al., 2015), Japan (Mutoh et al., 2017), Korea (Kwon et al., 2015; Park et al., 2014) and the Netherlands (Angsupaisal et al., 2015). Convenience samples of children were recruited from the hospitals, schools, or treatment centers that provided treatment for cerebral palsy. In children with cerebral palsy, the most rapid improvements in gross motor function occur within the first four years of life, with children reaching a relative plateau between ages 5 to 6 years of age, depending on the degree of disability (Mutoh et al., 2017; Park et al., 2014). This developmental knowledge impacted the age groups of children studied by researchers. Common inclusion criteria included certain age ranges, a diagnosis of cerebral palsy, weighing at or less than a certain weight (35 to 40 kg), meeting the GMFC requirements, and the ability to

follow directions. Exclusion criteria included uncontrolled seizures, severe health issues, severe intellectual disability, known allergies, fear of horses, having recent botulism injection, dorsal rhizotomy, or orthopedic surgery. Sample sizes ranged from six (Angsupaisal et al., 2015) to 91 (Kwon et al., 2015).

Findings. Many researchers have found that hippotherapy improved sensorimotor outcomes, such as motor function, functional skills, and balance in children with cerebral palsy (Angsupaisal et al., 2015; Champagne et al., 2017; Kwon et al., 2015; Moraes et al., 2016; Mutoh et al., 2017; Park et al., 2014; Ratan et al., 2015). For example, in a randomized controlled trial, Kwon et al. (2015) studied the effect of hippotherapy in children with cerebral palsy, ages four to 10 years (N=91); the experimental group included children receiving hippotherapy along with standard treatment. They found that Gross Motor Function Class and balance improved significantly after eight weeks of hippotherapy (30-minute sessions two times a week totaling 16 sessions), compared with those in the control group who received only conventional physical therapy. Their findings are consistent with those in another randomized controlled study where Park et al. (2014) researched the effects of hippotherapy on gross motor function and functional performance in children with cerebral palsy, ages 3 to 12 years of age (N=55). The participants received 45 minutes of hippotherapy twice a week for eight weeks. The researchers showed that the hippotherapy intervention significantly improved gross motor function and functional performance in children, compared with those in control group receiving traditional physical therapy. The significant improvement in Pediatric Evaluation of Disability Inventory: Functional Skills Scale (PEDI-FSS) scores also suggests that hippotherapy may be useful to maximize the overall functional performance of children with cerebral palsy. In addition to the sensorimotor benefits, children reported enjoying the riding of the horses and felt

emotionally connected with the horses, which may be a strong motivator for encouraging engagement in the therapy sessions (Kwon et al., 2015).

Because of relative plateau and development factors, the majority of the researchers studied children within the preschool and school-age age ranges (Angsupaisal et al., 2015; Champagne et al., 2017; Kwon et al., 2015; Moraes et al., 2016; Park et al., 2014; Ratan et al., 2015). Across studies, researchers found that hippotherapy is an effective treatment method for these children. Mutoh et al. (2017) studied cerebral palsy patients, ages four through adolescents and found that the effectiveness of the hippotherapy was not affected by age or gender and explained that most of the previous research focused on younger ages because that is when the most rapid gross motor improvements occur. The researchers divided results by gross motor function class, but not age.

Limitations. Age inclusion criteria, ages of maximum improvement, and body weight limitations all determine which age categories hippotherapy most affect. In order to safely and actively be involved in hippotherapy, children must be able to follow directions, so the minimum age requirement in the reviewed studies was at least three years of age. According to Kwon et al. (2015), the most effective outcomes of the therapy is achieved when body weight of riders was less than 20% of the horse's total body weight; for example, if the therapy horse weighs 250 kg, the rider must be less than 50 kg.

Implications for practice. Findings across studies are applicable to clinical practice because they support that hippotherapy is an effective alternative treatment option for children with cerebral palsy (Angsupaisal et al., 2015; Champagne et al., 2017; Kwon et al., 2015; Moraes et al., 2016; Mutoh et al., 2017; Park et al., 2014; Ratan et al., 2015). Not only has hippotherapy improved physical outcomes as evidenced by improved gross motor function and

balance, it also improved cognitive outcomes, emotional bonding, and motivation to participate in the therapy (Kwon et al., 2015; Moraes, 2016). Mutoh et al. (2017) noted that limitations to hippotherapy are availability and feasibility. Hippotherapy is not a conventional therapy and requires extra resources, so there are fewer places that offer it and their locations are often far from children with cerebral palsy. Hippotherapy is also limited by the need for additional human resources, as compared to traditional therapy.

Aquatic therapy

Aquatic therapy definition. Aquatic therapy utilizes different properties of water to aid children with decreased postural control and muscle weakness by reducing joint loads (Fragala-Pinkham, Smith, Lombard, Barlow, & O'Neil, 2013). In addition to the benefits the water provides for the joints, children generally seem to enjoy the environment in the water, making children more motivated to participate (Fragala-Pinkham, et al., 2013). Aquatic therapy utilizes mechanical effects such as hydrostatic pressure, buoyancy, and hydrodynamic force to affect posture and muscle control. Buoyancy helps in therapy by decreasing the effect of gravity. By alleviating the force of gravity, children with cerebral palsy are able to perform task they would be unable to perform on land. Hydrostatic pressure focuses on muscle training whereas hydrodynamic influences balance and posture (Lai et al., 2014). In addition to the mechanical effects, the water also provides thermal effects. When the body is in warm water (33-35 degrees Celsius), the water is able to increase muscle elasticity and decrease spasticity by using its thermal effects to decrease gamma fiber activity (Adar et al., 2017).

Description of studies. Of the six studies reviewed about aquatic therapy, three were randomized controlled trials, generating level two of evidence (Adar et al., 2017; Dimitrijević, et al., 2012 Lai, et al., 2014;). Two of the studies were quasi-experimental, generating level four of

evidence (Aidar et al., 2007; Fragala-Pinkham, et al., 2014). Only one of the studies was a case control study generating a level four of evidence (Retarekar, Fragala-Pinkham, & Townsend, 2009). Researchers conducted studies in the United States (Fragala-Pinkham, et al., 2014; Retarekar et al., 2009), Brazil (Aidar et al., 2007), Taiwan (Lai, et al., 2014), Turkey (Adar et al., 2017) and Serbia (Dimitrijević, et al., 2012). Convenience samples of children were recruited from hospitals, schools, and rehabilitation centers internationally for cerebral palsy. In order to participate in the studies, children had to meet inclusion criteria. Common inclusion criteria included being under the age of 18, ability to follow commands, having symptoms of cerebral palsy, falling within gross motor function requirements, and agreeing to participate in the study. Exclusion criteria included intellectual developmental disorders or autism, infections, open untreated wounds, surgery or botulinum toxin injections within the past six months, and uncontrolled seizure activity. Sample sizes ranged from one (Retarekar et al., 2009) to 32 (Adar et al., 2017). The length of intervention delivery time period ranged from 6 weeks (Adar et al., 2017; Dimitrijević, et al., 2012) to 16 weeks (Aidar et al., 2007). The shorter lasting intervention times required more participation throughout the week, such as in the six week study they met five times a week (Adar et al., 2017) versus the longer intervention times that only required children to participate in an hour to an hour and a half of activity weekly (Aidar, 2007; Fragala-Pinkham, et al., 2014; Lai, et al., 2014).

Findings. All of the researchers found improvements in the children who participated. Children showed improvements in gross motor skills, quality of life, functional skills, enjoyment and balance (Adar et al., 2017; Aidar et al., 2007; Dimitrijević, et al., 2012; Fragala-Pinkham, et al., 2014; Lai, e t al., 2014; Retarekar et al., 2009;). For example, Aidar, et al. (2017) conducted a randomized controlled trial which studied the effect of aquatic therapy in children with cerebral

palsy, ages four to seventeen years of age (N=32). There were two groups, the group that received the intervention had 17 participants and the control group had 15 participants. The participants had five 60-minute sessions for six weeks that were composed of the same exercises with individualized intensities. The researchers found that gross motor function improved in all participants (including the control group) after six weeks but the group that participated in aquatic therapy had a greater improvement in quality of life.

All researchers compared data from before treatment, during treatment, and after treatment to determine outcomes. Outcome measures varied from study to study (Adar et al., 2017; Aidar et al., 2007; Dimitrijević, et al., 2012; Fragala-Pinkham, et al., 2014; Retarekar et al., 2009; Lai, et al., 2014). Adar et al. (2017) measured daily living outcomes with the Pediatric Quality of Life Inventory scale, where Lai et al. (2014) measured activities of daily living and enjoyment with Modified Ashworth Scale and the Physical Activity Enjoyment Scale. Overall, all researchers found that aquatic therapy improved gross motor function regardless of the severity of cerebral palsy. Across studies, researchers found that aquatic therapy is an effective alternative treatment method for children under the age of 18. Adar et al. (2017) studied cerebral palsy patients, age four through adolescents and found no statistically significant differences in participants age and gender related to the outcomes of treatment.

Limitations. Common limitations included smaller samples, short intervention delivery time frames, lack of control group, immediate rather than maintained effects, and a lack of available resources such as pool availability and human resources. The research did not include children with cerebral palsy classified at severity level five on the GMFCS

Implications for practice. Findings are important for clinical practice because they provide evidence that alternative therapies such as aquatic therapy can provide better treatment

outcomes when used as a form of therapy for children with cerebral palsy. By using these therapies in clinical settings, children's quality of life and enjoyment of treatment may improve significantly. Unfortunately, due to limited availability, aquatic therapy may be difficult to access for many children with cerebral palsy.

Robotic gait training

Therapy description. Robotic assisted gait training is the use of mechanical devices to increase walking abilities for those with cerebral palsy. Robotic gait training has become increasingly more common as a rehabilitation tool over the last decade to improve the gait pattern of people with neurological impairment (Lefmann, Russo, & Hillier, 2017). Robotic gait training stimulates real life gait scenarios and trains for control of different movements associated with gait (Bayon et al., 2018). Children with CP are placed into these robotic devices with body weight and postural support. One major benefit is that the therapy can be individualized based on level of disability. The repetition of the movement and support generates proper movement to improve walking abilities. There are several robotic assisted gait training devices on the market. This systematic review will discuss results from studies of the CPWalker and Lokomat®Pediatric devices. The CPWalker is a robotic device composed by an exoskeleton linked to a walker that provides support and balance to the child during over-ground training (Bayon et al., 2018). The Lokomat supports an adult or child upright on a treadmill while using robotics to move his/her legs to simulate walking (Wiart, 2016).

Description of studies. Four studies analyzing robotic gait training included children with cerebral palsy classified between I and IV on the GMFCS. Participants were diverse including an assortment of clinical presentations. Age ranges were from three years to 19 years. There are limitations to body length and weight with the mechanical devices to make it safe. van

Hedel, H. J. A., Meyer-Heim, A., & Rüsch-Bohtz, C. (2016) required femur length at least 21 cm and body weight less than 135 kg. Bayon et al. (2018) required body weight less than 75 kg. It was also required that the children with cerebral palsy be capable of understanding the purpose of the exercise and signal pain or discomfort. Exclusion criteria included severe lower extremity contractures, fractures, osseous instabilities, osteoporosis, severe disproportional bone growth, unhealed skin lesions, thromboembolic disease, cardiovascular instability, mechanical ventilation, severe cognitive deficits, and aggressive and self-harming behaviors. Researchers of robotic gait training studied varied sample sizes from two (Bayon et al., 2018) to 67 (van Hedel et al., 2016). Two studies were quasi-experimental generating level 6 evidence 6 (Bayon et al., 2016; Bayon et al., 2018). Two studies were random control trials generating level 2 evidence (Wallard Dietrich, Kerlirzin, & Bredin, 2017; van Hedel Meyer-Heim, & Rüsch-Bohtz, 2016). Convenience samples were enlisted from hospitals and treatment centers in Spain (Bayon et al.2016; Bayon et al., 2018) Switzerland (van Hedel et al., 2016), and Belgium (Wallard et al., 2017); therefore, no research studying cerebral palsy and this innovative treatment was found in the United States.

Findings. Collectively, researchers found improvements in gait and balance after the use of robotic gait training devices. Improvements included gait pattern execution, independence, and decreased need of body weight support (Bayon et al. 2016; Bayon et al. 2018; Van Hedel et al., 2016; Wallard et al. 2017). For example, in Bayon et al. (2016), two children with CP were evaluated for percentage of normal gait pattern and percent of body weight support after five weeks of robotic gait training. Both children improved in those clinical areas. Their findings are consistent with those of a random control trial where van Hedel et al. (2016) conducted an average of 20.3 sessions with an average of 25 minutes of walking per session using the

Lokomat. Van Hedel et al. (2016) observed increased gait independence with the use of the mechanical device compared to no significant improvement findings in children who underwent regular physical therapy. Wallard et al. (2017) evaluated 30 children with CP and observed development of new gait strategies and improvements in walking and standing in the group using robotic gait training. It is highlighted in each of the studies (Bayon et al. 2016; Bayon et al. 2018; Van Hedel et al., 2016; Wallard et al. 2017) the need to tailor the therapy to particulars of each child. A variety of outcome measures were used to evaluate the effectiveness of treatment. The most common were the 10-meter walk test, six-minute walk test, and the Gross Motor Function Measurement with a focus on dimensions standing and walking (Bayon et al., 2018; Bayon et al., 2016, Hedel et al., 2016; Wallard et al., 2017). Bayon et al. (2016) and Bayon et al. (2018) used a 3-dimensional motion capture system to measure walking performance of the children. Wallard et al. (2017) used the VCON-Nexus and Motion Inspector software to calculate the upper and lower body kinematics. Overall and regardless of outcome measures, results show positive improvements of postural and locomotor function in children with CP. The ideal age group for this therapy is based on the child's physical stature and cognitive abilities. These devices have also been used by the adult population for stroke rehabilitation. The research discussed in this systematic review did not analyze effects on children under the age of three, therefore, age groups of school age children and older were found to benefit from this therapy.

Limitations. All of these studies have methodological limitations which impact the limitations of research findings. The smaller samples decreased generalizability of findings and were not valid for statistical analysis, generating weaker evidence to make strong conclusions for practice. For example, diversity of CP severity cannot be represented with smaller samples. Large samples in random control trials are needed to generate higher levels of evidence for

practice. The researchers also analyzed immediate outcome data rather than data for sustained or maintenance outcome. Therefore, there is no evidence supporting lasting effects of robotic assisted gait training. Further, use of quasi-experimental studies limited evidence for practice (Bayon et al. 2016; Bayon et al., 2018), which reduces the validity of the experiments.

Implications for practice. Overall, it was determined through the analysis of the studies that robotic assisted gait training has positive outcomes, however, evidence does not support this therapy as an alternative to physical therapy, but it may be beneficial as a complementary therapy. The methodological limitations across studies makes it difficult to come to definitive conclusions on the effectiveness of robotic gait training on balance and gait. Treatment using robotic gait training may be dependent on the intensity of the training protocol which is determined by individualized patient needs. These studies may be better used for understanding how to integrate robotic gait training rehabilitation in improving motor function in children with CP. With little research of this innovative therapy, there is no conclusion of standardized practice. However, it is clear that individuality of the children with CP needs to be taken into consideration with this therapy.

Critical Appraisal of Evidence

Research focused on aquatic therapy, hippotherapy, and robotic gait training in children with cerebral palsy has been reviewed and evaluated based on 20 studies. In these studies, several limitations were found. One overwhelming limitation is the absence of long-term evaluation. No studies in this systematic review evaluated long term effects of the therapy after the therapy was discontinued. Therefore, it cannot be determined by these studies that there are lasting effects of treatment. Another limitation across all studies is sample size. Retarekar et al., (2009) included one participant, Bayon et al., (2016) included two participants and the largest

sample size was Kwon et al.'s (2015) study which included 91 participants. Small sample sizes generate weaker evidence and makes it difficult to make strong conclusions for practice.

Each of the studies required inclusion and exclusion criteria which limits the prospective subjects. The ability for the participating child to understand and express pain or discomfort was a requirement consistently throughout the studies. For robotic gait training participants had to be of a specific weight or size in order to safely participate in therapy. Similarly, hippotherapy had certain weight restrictions. Further, participation in each of the studies focused on children with CP between gross motor functions of levels one to four. The studies excluded level five, whom require maximum body weight support.

Each of the alternative therapies requires various equipment and space. Hippotherapy utilizes trained personal that keep the patient and the horse safe from injury. This can take up to four people at a time and can be limited by the lack of human resources. Aquatic therapy requires water that is easily accessible for individuals with CP. The lack of available facilities limits the accessibility for many children. Robotic gait training is a new alternative therapy with all studies in this systematic review conducted in Europe. Due to the expense of the equipment there are few rehabilitative facilities able to finance this therapy.

Another limitation was the use of research designs that excluded a control group (Aidar et al., 2007; Bayon et al., 2016; Bayon et al., 2018, Eliso, 2017; Fragala-Pinkham, et al., 2014; Hedel et al., 2016, Kwon et al., 2015; Park et al.,2014; Retarekar et al., 2009). The purpose of a control group is to evaluate participants who receive only traditional therapy or no therapy at all, so the results could be compared with the results from the individuals receiving the alternative therapies. Without the results of a control group, it is difficult to determine if the changes came as a direct result from the alternative therapy treatment. While cerebral palsy is a disorder that

presents differently in severity and affect between individuals, the results of the studies can be generalized more if the studies are adequately designed and implemented.

The studies used evaluation scales to determine effectiveness of treatment. These tools require the assessment of individuals, which can result in evaluator bias. Not all analysts were blinded from the progress of the child in therapy (Angsupaisal et al., 2015; Champagne et al., 2017., Eliso, 2017, Hedel et al., 2016, Retarekar et al., 2009). Those who support the therapy may also have a predisposed belief of its positive effects, which can alter their judgements. In addition, C. Bayon et al. (2016) and Bayon (2018), were involved in the development of the CPWalker, which creates a bias for its success in the field. Bayon et al. (2016), Bayon et al. (2018), and Wallard (2017), all utilized electronic systems for evaluation along with human evaluation to determine outcomes. The use of the electronic systems eliminates bias in those recorded results. These devices were not used in hippotherapy or aquatic therapy.

Sampling methods across all of the research studies were through convenience sampling. This is a non-probability sampling that utilizes the population that is within geographic convenience. Convenience sampling was used because there are a limited number of cerebral palsy patients that fulfilled the inclusion and exclusion criteria in the studies with accessibility to the clinical setting. This makes the studies deeply vulnerable to selection bias and decrease their credibility. Robotic gait training studies appraised in this systematic review were found in various countries excluding the United States. The studies on hippotherapy and aquatic therapy were conducted in both the United States and abroad.

Each of the studies are categorized in levels of evidence, which is determined by how the experiment is executed. Levels of evidence across the 20 studies range from level one to level six. Level one is the most scientifically significant. This helps the reader determine if results are

reliable or valid. Quasi-experimental design studies are used to determine the impact of an intervention on a specific population without random assignment. Because of this, these studies are ranked as a level of evidence IV. For example, in a study conducted by Lai et al. (2014) they divided participants into two groups, a control and a treatment group, which was decided by participants preference. Another quasi-experimental study conducted by Mutoh et al. (2017), evaluated the effects of hippotherapy treatment on pediatrics with cerebral palsy without a control group. Quasi-experimental studies are used for conditions in which the treatment and control groups may not be comparable at baseline.

Wallard et al. (2017), is a random control trial that included a control group with 16 children and a treated group with 14 children. This random selection trial was a two-group pretest posttest design and generates findings between the two groups and the individuals before and after the treatment. This experiment generates a level of evidence II and can be used to determine significant effects of alternative therapy compared to traditional therapy.
Brandao et al. (2014) is a descriptive study in which no variables were manipulated but rather observed by the researchers. Brandao et al. (2014) conducted a survey including 75 participants focusing on the priority care within traditional therapy. These designs allow for rapid data collection but lack the ability to establish causality.

Synthesis of Evidence

Cerebral palsy can negatively impact a person's motor function and balance leading to a decreased quality of life. The 20 studies reviewed in this systematic review all found that hippotherapy, aquatic therapy or robotic gait training were effective as alternative therapies or when used in addition to traditional therapy. By using these alternative therapies patients of the pediatric population had greater improvement in motor function and balance than if they had

only received a traditional therapy. Across the studies there were no significant gaps of evidence to suggest that the alternative therapies did not lead to a positive improvement in a patient's motor function. Although there is a need for further research on these alternative therapies, evidence from the 20 studies critically appraised suggest that these therapies may have positive effects on activities of daily living.

Recommendations

Nursing considerations

As a nurse, it is important to be educated on appropriate resources and care options available to patients. Advanced practice nurses also need to be educated on therapy options because they may be recommending, referring, or ordering therapy. The literature reviewed on hippotherapy, aquatic therapy, and robotic gait training revealed that each therapy has positive effects on both the gross motor function and balance in pediatrics with cerebral palsy. The research has suggested that these three therapies are all effective when used as an alternative therapy or as an adjunctive therapy in addition to traditional therapy.

When determining which of these three therapies would be best for a child with cerebral palsy, there are several factors to consider. First, the patient's Gross Motor Function Classification level needs to be considered. If the patient is a level 5 on the GMFC scale, then these alternative therapies are not appropriate for the patient. Robotic gait training is focused on rehabilitation with levels 2 through 4, so it would not be appropriate for a patient with a level 1 classification (Bayon et al. 2016; Bayon et al. 2018; Van Hedel et al., 2016; Wallard et al. 2017). Hippotherapy and aquatic therapy can be utilized for individuals in classifications 1 through 4 (Adar et al., 2017; Aidar et al., 2007; Angsupaisal et al., 2015; Champagne et al., 2017; Dimitrijević, et al., 2012; Fragala-Pinkham, et al., 2014; Kwon et al., 2015; Lai, e t al., 2014;

Moraes et al., 2016; Mutoh et al., 2017; Park et al., 2014; Ratan et al., 2015; Retarekar et al., 2009). After ruling out therapies that are not appropriate for the GMFC levels, the availability and cost of the therapies need to be researched. Therapies may have to be paid for out of pocket by the client's family or covered by insurance. Finally, after GMFC level, availability, and cost are reviewed, what interests the child can be considered. After the child has started therapy, the nurse and medical staff who come in contact with the patient should watch for signs to see if the therapy is effective and to see if the improvements are maintained for longer periods of time.

Future Studies Recommendations

There are some limitations to the current studies reviewed that need to be addressed in future studies on hippotherapy, aquatic therapy, and robotic gait training. Of the studies reviewed, the longest studies were 26 weeks. Future studies need to be conducted over longer periods of time and include findings on long term effects. Studies should be conducted using blind interpretation of data and unbiased researchers. Future studies should also include larger sample sizes with control groups. These larger studies should evaluate the effects of the therapies on each specific GMFC level, age, developmental level, and gender. Cultural implications on the therapies need researched to determine if they impact the results. Future studies should also assess factors such as therapy accessibility and cost.

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Appendix A: Systematic Review Table of Evidence [1]

APA formatted reference	Purpose statement. Research question[2].	Clinical Practice Setting, Sampling methods, Sample size[3].	Design. Level of Evidence.[4]	Findings, Conclusion[5]	Practice & Research Implications[6]	Limitations of Findings[7]
Hippotherapy						
Angsupaisal, M., Visser, B., Alkema, A., Meinsma-van der Tuin, M., Maathuis, C. G. B., Reinders-Messelink, H., & Hadders-Algra, M. (2015). Therapist-designed adaptive riding in children with cerebral palsy: Results of a feasibility Study. *Physical Therapy*, *95*(8), 1151–1162. https://doi-org.ezproxy.uakron.edu:2443/10.2522/ptj.20140146	Purpose Statement: "The study aim was to explore the feasibility of an extensive assessment protocol for a randomized controlled trial of therapist-designated adaptive riding (TDAR) in children with CP, with the goals of assessing the effects on child outcomes and evaluating working mechanism of sitting postural control. " (pg. 1151) Research Question: Is it possible to establish a complex protocol for a randomized control trial of TDAR in children with CP?	Clinical Practice Setting: Indoor arena of the Riding Center Onder de Linde and Rehabilitation Center Revalidatie Friesland Sampling methods: Recruited from Rehabilitation Center Revalidatie Friesland based on the criteria: between 6-12 years old with spastic CP, Gross Motor Function Class System (GMFM-88) of II or II and ability to follow verbal instructions. Sample size: 6 children (1 girl, 5 boys)	Design: Randomized Controlled Trial Level of Evidence: 2	Findings: The average GMFM-88 score increased. The change scores for all children exceeded the level required to be considered as clinically important difference in the GMFM-88 score. 5 of the 6 children showed a decrease in posture difficulties stereotypical of CP. Conclusion: The protocol was feasible. 6-weeks of TDAR improved the gross motor functions and reduced posturing.	Practice & Research Implications: TDAR improved the gross motor function and posture control, so it is a useful alternative treatment that can be used for children with CP.	Limitations of Findings: -Small sample size -No control group -No blinding- allows for bias -Assessment made post intervention and doesn't reveal long term effects

Champagne, D., Corriveau, H., & Dugas, C. (2017). Effect of hippotherapy on motor proficiency and function in children with cerebral palsy who walk. *Physical & Occupational Therapy In Pediatrics*, *37*(1), 51-63. https://doi-org.ezproxy.uakron.edu:2443/10.3109/01942638.2015.1129386	Purpose Statement: "To evaluate the effects of hippotherapy on physical capacities of children with cerebral palsy." (pg. 51) Research Question: How effective is hippotherapy on the motor proficiency and function in children with cerebral palsy who walk?	Clinical Practice Setting: Centre d'apprentissage en thérapie équine du Québec Sampling methods: recruited through rehabilitation centers in Quebec using ads in institutional and local papers. Required to be between 4 and 16 years old, be diagnosed with diplegia or spastic hemiplegia, have Gross Motor Function Classification System level of I or II, and ability to follow verbal directions. Sample size: 13 Children	Design: Quasi-experimental design Level of Evidence: 4	Findings: After 10 weeks of hippotherapy, 30 minutes per week, the GMFM-88 scores, three out of the eight items of fine motor precision, balance, and strength showed improvement immediately after intervention; the mean scores 10 weeks after the intervention showed the same improvements Conclusion: 10 weeks of hippotherapy improved body functions and performance of GM and fine motor activities in children with cerebral palsy who can walk.	Practice & Research Implications: The study concludes that hippotherapy improves motor function in CP patients ages 4-12 with GMFM-88 of I and II, who had stopped all other therapy during the hippotherapy sections, so hippotherapy is a positive alternative to traditional therapy in children with CP who can walk. It should be studied more and introduced to therapists as a possible part of the treatment plan.	Limitations of Findings: -Smaller study -No blinding -No control group

Kwon, J., Chang, H. J., Yi, S., Lee, J. Y., Shin, H., & Kim, Y. (2015). Effect of hippotherapy on gross motor function in children with cerebral palsy: A randomized controlled trial. *Journal Of Alternative & Complementary Medicine*, *21*(1), 15-21. https://doi-org.ezproxy.uakron.edu:2443/10.1089/acm.2014.0021	Purpose Statement: "To examine whether hippotherapy has a clinically significant effect on gross motor function in children with cerebral palsy." (pg. 15) Research Question: What effect does hippotherapy have on gross motor function in children with cerebral palsy?	Clinical Practice Setting: Samsung Medical Center and indoor riding arena in Gyeonggi-do Republic of Korea Sampling methods: Identified through Samsung Medical Center Database and meeting the criteria of CP diagnosis, body weight less than 35 kg, and between 4 and 10 years old. Exclusion criteria included having a botulism injection in the past 6 months, severe intellectual disability, uncontrolled seizures, and poor visual or hearing acuity. Sample size: 91 children (45 in intervention group, 46 in control group)	Design: Randomized Controlled Trial Level of Evidence: 2	Findings: The measures of GMFM-88, GMGM-66, and the Pediatric Balance Scale significantly differed between the intervention and control groups after the 8-week study period. The GMFM-88 scores improved significantly after hippotherapy. The level of improvement varied based on the GMFCS level. . Conclusion: Hippotherapy positively affects gross motor function and balance in children with CP with a variety of functional levels.	Practice & Research Implications: When hippotherapy is provided by licensed health professionals, it is beneficial on gross motor function and balance in children with CP, so it may be used as a treatment option for CP patients with a variety of functional levels.	Limitations of Findings: -Didn't control participants' other therapeutic activities or conventional physiotherapy -Assessment made post intervention and doesn't reveal long term effects

Moraes, A. G., Copetti, F., Angelo, V. R., Chiavoloni, L. L., & David, A. C. (2016). The effects of hippotherapy on postural balance and functional ability in children with cerebral palsy. *Journal Of Physical Therapy Science, 28*(8), 2220–2226. https://doi-org.ezproxy.uakron.edu:2443/10.1589/jpts.28.2220	Purpose Statement: This study evaluated the effects of hippotherapy on seated postural balance, dynamic balance, and functional performance in children with cerebral palsy and compared the effects of 12 and 24 sessions on seated postural balance" (pg. 2220). Research Question: How effective is hippotherapy on seated postural balance, dynamic balance, and functional performance in children with cp at 12 weeks versus 24 weeks?	Clinical Practice Setting: Hippotherapy Center of the Federal District Military Police, Brasilia, Brazil Sampling methods: Non-probabilistically recruited from hippotherapy center waiting lists; physical therapy clinics; and medical, physical, and occupational therapist referrals. Inclusion criteria included cp diagnosis, between 5 and 10 years old, understanding of simple commands, ability to remain seating without help for at least 10 seconds. Exclusion criteria based on previous treatment and inability to follow commands. Sample size: 15 (12 males, 3 females)	Design: Quasi-experimental design Level of Evidence: 4	Findings: Significant improvements were observed for center of pressure variables, including mediolateral, anteroposterior displacement, and velocity of displacement, after 12 weeks, and to a greater extent after 24 weeks. There were also significant increases associated with functional skills (self-care, social function, and mobility), caregiver assistance (self-care), social function, and overall mobility. Conclusion: Hippotherapy resulted in improvements to postural balance in a sitting position, dynamic balance, and functionality. The positive effects are even more improved after 24 hippotherapy sessions.	Practice & Research Implications: The hippotherapy caused greater improvements after 24 weeks of therapy, so it may be a good longer term therapy choice for cp patients.	Limitations of Findings: -Small sample size -No control group

Mutoh, T., Mutoh, T., Tsubone, H., Takada, M., Doumura, M., Ihara, M., … Ihara, M. (2018). Impact of serial gait analyses on long-term outcome of hippotherapy in children and adolescents with cerebral palsy. *Complementary Therapies in Clinical Practice, 30*, 19–23. https://doi-org.ezproxy.uakron.edu:2443/10.1016/j.ctcp.2017.11.003	Purpose Statement: "The aim of this study was to obtain data of gait parameters on predicting long-term outcome of hippotherapy." (pg. 19) Research Question: What are the long-term gait effects of hippotherapy on children and adolescents with cerebral palsy?	Clinical Practice Setting: Holistic Betterment and Wellness Through Riding PIROUETTE riding center Sampling methods: Participants ages 4-19 years old were recruited through their specialty schools, physiotherapy services, and general hospitals. Required to be able to walk, have diagnosis of bilateral spasticity, GMFCS of I to III, have no orthopedic problems that would obstruct training for 30 minutes. Exclusion criteria was mobility influencing surgery within past 6 months, botulinum toxin injection within last 3 months or dorsal rhizotomy within past year, impairments or medical conditions that contraindicate the therapy, and	Design: Quasi-experimental design Level of Evidence: 4	Findings: After the 1-year intervention the GMFM-66 score significantly improved. The outcome of hippotherapy treatments, when measured with the GMFM- 66, was not affected by age, female gender, presence of intellectual disability, or baseline GMFCS level. Conclusion: Hippotherapy was associated with increased Gross Motor Function Measure (GMFM)-66 at 1 year with increased stride length, walking speed, and mean acceleration and decreased horizontal/ vertical displacement ratio over time. Stride length and mean acceleration, measured at 6 weeks, predicted the	Practice & Research Implications: Hippotherapy is an effective long-term therapy option. The long-term effects can be predicted based on testing scores after just 6 weeks of therapy.	Limitations of Findings: -Single-arm design (results may not represent all types and severity levels of CP) -No control group -Relatively small sample group

		known allergy to or fear of horses. Sample size: 20 (10 males, 10 females.)		elevation of GMFM-66 score.		

Park, E. S., Rha, D. W., Shin, J. S., Kim, S., & Jung, S. (2014). Effects of hippotherapy on gross motor function and functional performance of children with cerebral palsy. *Yonsei Medical Journal, 55*(6), 1736–1742. https://doi-org.ezproxy.uakron.edu:2443/10.3349/ymj.2014.55.6.1736	Purpose Statement: "The purpose of our study was to investigate the effects of hippotherapy on gross motor function and functional performance in children with spastic cerebral palsy (CP)." (pg. 1736) Research Question: What are the effects of hippotherapy on gross motor function and functional performance in children with cerebral palsy?	Clinical Practice Setting: Riding center in Seoul Race Park Sampling methods: Recruited if met criteria. Inclusion criteria included being between 3 and 12 years old, body weight less than 40kg, GMFCS level I to IV. Exclusion included cheodenervation therapy in past 6 months, moderate to severe intellectual disability, uncontrolled seizures, and poor visual or hearing acuity. Sample size: 34 children (15 males, 19 females) and control group of 21	Design: Randomized Controlled Trial Level of Evidence: 4	Findings: After 8 weeks of hippotherapy, the mean GMFM-66 and GMFM-88 scores were improved in both the intervention and control groups. The hippotherapy group showed significantly greater improvement in the GMFM-66 total score than the control group did. The total PEDI-FSS score and its 3 sub-domains were significantly improved in the hippotherapy group, but not in the control group. Conclusion: Hippotherapy intervention had more beneficial effects on gross motor function and functional performance in children with CP than the control group did The significant improvement in	Practice & Research Implications: Hippotherapy is effective at improving the gross motor function and overall functionality in daily living in children with CP, so it is a viable therapy option for this population.	Limitations of Findings: -Small sample size, so unable to group children by GMFCS level -Didn't control therapeutic interventions other than physical and occupational

				PEDI-FSS scores suggests that hippotherapy may be useful to maximize the functional performance of children with CP.		

Ratan Purohit, R., Jayprakash Vyas, N., & Sandeep Sheth, M. (2015). Effect of hippotherapy on balance and function in children with spastic diplegia. International Archives of Integrated Medicine, 2(3), 1–7. http://search.ebscohost.com.ezproxy.uakron.edu:2048/login.aspx?direct=true&db=a9h&AN=101808523&site=ehost-live	Purpose Statement: "The study aimed to find the effect of hippotherapy on balance and function in children with spastic diplegia." (pg 1) Research Question: How does hippotherapy affect balance and function in children with spastic diplegia CP?	Clinical Practice Setting: College of Physiotherapy, V.S. Hospital, Ahmedabad Sampling methods: Purposive sampling ages 3- 10 years. Inclusion criteria was GMFCS between I and II and body weight less than 35 kg. Exclusion criteria was dorsal rhizotomy, orthopedic surgery within last year, botulism injection within last 6 months, moderate to severe intellectual disability, and poor visual or hearing acuity. Sample size: 16 (8 in control, 8 in experimental, two children dropped out from each group mid-study, leaving a total of 12)	Design: Quasi-experimental Design Level of Evidence: 4	Findings: There was significant increases in the GMFM score in the experimental group upon post-test, but there was not a significant difference in the PBS scores between the groups post-tests. Conclusion: Hippotherapy and Neurodevelopmental Therapy NDT (control) both had similar "effects of improved balance in spastic diplegic children, but hippo therapy has an additional effect for improving gross motor function." (pg. 2)	Practice & Research Implications: Hippotherapy in addition to regular physiotherapy can be extra beneficial for patients with cp, so it is a valid treatment option.	Limitations of Findings: -Small sample size -No follow up on long term effectiveness of hippotherapy
Aquatic Therapy						

Adar, S., Dündar, Ü., Demirdal, Ü. S., Ulaşlı, A. M., Toktaş, H., & Solak1, Ö. (2017). The effect of aquatic exercise on spasticity, quality of life, and motor function in cerebral palsy. *Turkish Journal of Physical Medicine & Rehabilitation (2587-0823)*, *63*(3), 239–248. https://doi-org.ezproxy.uakron.edu:2443/10.5606/tftrd.2017.280	Purpose Statement: "The primary aim of this study was to compare the effects of aquatic exercises and land-based exercises on spasticity, quality of life, and motor function in children with cerebral palsy (CP). The secondary aim was to assess the morphology of spastic muscle using ultrasonography." (pg. 239) Research Question: How do the effects of aquatic therapy compare to land-based exercises to improve quality of life and motor function in patients with CP.	Clinical Practice Setting: Rehabilitation centers in Turkey- some studies done in the pool others done outside of the pool on land Sampling methods: Two Groups- Aquatic therapy was considered the group with the intervention and was composed of 17 participants versus the land-based exercises were considered to be the controlled and were composed of 15 participants. They were recruited from the university Sample size: 32 patients (17 boys and 15 girls)	Design: Randomized Control Study Level of Evidence: 2	Findings: . There were no significant differences in functional outcome measures in the data collected between the group that underwent interventions and the control group. However, the subjects who underwent aquatic therapy showed greater improvements in quality of life scores and the results showed that there was more enjoyability. Conclusion: Aquatic exercises can lead to a higher quality of life for patients with CP versus land-based therapy. But aquatic exercise and land-based therapy seem to have the same effect on muscle spasticity.	Practice & Research Implications: Although the findings for the two groups had similar results, aquatic therapy proved to be more beneficial in some ways to the patients and the patient's families. This enforces the importance of aquatic therapy in patients suffering from CP.	Limitations of Findings: The main limitation was the small sample size, short length of study (only 6 weeks), all participants had low GMFCS and researchers were unable to check in with patients to see if they maintained improvements.

Aidar, F. J., Silva, A. J., Reis, V. M., Carneiro, A. L., Vianna, J. M., & Novaes, G. S. (2007). Aquatic activities for severe cerebral palsy people and relation with the teach-learning process. *Fitness & Performance Journal (Online Edition)*, *6*(6), 377–381. https://doi.org/10.3900/fpj.6.6.377.e	Purpose Statement: "To evaluate the area of the social function in cerebral palsy carriers submit to one program of aquatic physical activities, adopting itself Pediatric Evaluation Disability Inventory – PEDI, and manual abilities." (pg. 377) Research Question: How can aquatic therapy over a 16-week period improve PEDI function and gross motor skills and paper and pencil abilities in children with severe CP	Clinical Practice Setting: No specific location but the pool was described as a 25 X 12.5 M Sampling methods: Pediatrics with severe cerebral palsy were selected from Sample size: 21 children 9 females and 12 males ranging from 6 to 12 years of age	Design: Quasi-experimental design Level of Evidence: 4	Findings: The PEDI score standard deviation increased by approximately 13 and the paper and pencil ability increased by .67. Conclusion: After 16 weeks of aquatic therapy the improvements gained by the therapy allowed for greater independence for patients that participated. There is a large improvement in motor and social function.	Practice & Research Implications: "This demonstrates that the aquatic physical activities were important for the process teaching-learning and it comes as a form of promoting a larger independence, larger manual ability, with a consequent social participation more it executes in the individual with Cerebral Palsy." (pg. 381)	Limitations of Findings: Small sample size, different severities of CP, short study time

Dimitrijević, L., Aleksandrović, M., Madić, D., Okičić, T., Radovanović, D., & Daly, D. (2012). The Effect of Aquatic Intervention on the Gross Motor Function and Aquatic Skills in Children with Cerebral Palsy. *Journal of Human Kinetics,32*, 167-174. doi:DOI:10.2478/v10078-012-0033-5	Purpose Statement: "The objective of this study was to investigate the effect of an aquatic intervention on the gross motor function and aquatic skills of children with cerebral palsy (CP)." Research Question: How do gross motor function outcomes differ between children with cerebral palsy who undergo aquatic therapy versus traditional therapy?	Clinical Practice Setting: A rehabilitation center in Nis Serbia Sampling Methods: Children aged 5-14 were recruited from MD practitioners from the University Clinical Center Physical Medicine and Rehabilitation Clinic Paediatric Department and City Society. Children had to be able to follow commands and have had no Botox injections surgery or contraindicated medical conditions Sample Size: 29 (13 children served as a control and 14 participated)- two children dropped out of the study	Design: Randomized control study Level of Evidence: 2	Findings: After a six-week study with two 55-minute sessions per session the children who received aquatic therapy had improvement during treatment unfortunately these children showed no long term improvements Conclusion: Aquatic therapy has the ability to improve gross motor function outcomes for children suffering from cerebral palsy	Implications for practice: "Aquatic physical activity has strong potential to benefit children with CP (Gerter and Currie, 2011). Despite the fact that swimming is one of the most frequently reported physical activities in children and adolescent with CP"	Limitations of research: -small sample size -age group limitations -time frame

Fragala-Pinkham, M. A., Smith, H. J., Lombard, K. A., Barlow, C., & O'Neil, M. E. (2014). Aquatic aerobic exercise for children with cerebral palsy: a pilot intervention study. *Physiotherapy Theory & Practice*, *30*(2), 69–78. https://doi-org.ezproxy.uakron.edu:2443/10.3109/09593985.2013.825825	Purpose Statement: "The primary purpose of this pilot study was to evaluate the effectiveness of a 14-week aquatic exercise program on gross motor function and walking endurance in children with cerebral palsy (CP). The secondary purpose was to evaluate changes in functional strength, aerobic capacity and balance. The secondary purpose of this pilot study was to evaluate changes in functional strength, aerobic capacity and balance" (pg. 69) Research Question: How does a 14-week aquatic exercise program affect gross motor function and walking endurance in children with CP	Clinical Practice Setting: Recruited from Franciscan hospital and participated in study in a rehab center in the pool Sampling methods Recruited from Franciscan hospital and E-flyers sent to PT and OT therapist at public schools: Sample size: 8 ambulatory children aged 6-15. 3 were classified as a level I and five were classified as a level III	Design: Case-control study Level of Evidence: 4	Findings: No changes were measured from baseline measurement 1 and baseline measurement 2. Significant improvement was measured by the PT administering different test to look for gross motor improvement. Significant improvement was seen from baseline measurement 1 and 2 to the measurement at the end of the 14-week intervention. No increased improvement was seen from 14-week measurement to one-month post research measurement but subjects maintained their improvements. Conclusion: By adding aquatic exercises to children with CP therapy there was a significant increase in gross motor	Practice & Research Implications: The study demonstrates the importance of alternative therapies specifically aquatic therapy in the treatment of pediatrics with CP.	Limitations of Findings: lack of strong post-study evidence that the the improvements from therapy would be maintained, lack of participants thoughts and ideas on the therapy, lack of time, length of session times varied due to participants energy/strength, lack of a control group, and small sample size

				function, such as walking, after the therapy was performed. After the study the participants were able to maintain these improvements. In addition, patients found increased enjoyment. The study found no specific age that gained more benefits from this therapy than the other.		

Lai, C.-J., Liu, W.-Y., Yang, T.-F., Chen, C.-L., Wu, C.-Y., & Chan, R.-C. (2015). Pediatric aquatic therapy on motor function and enjoyment in children diagnosed with cerebral palsy of various motor severities. *Journal Of Child Neurology*, *30*(2), 200–208. https://doi-org.ezproxy.uakron.edu:2443/10.1177/0883073814535491	Purpose Statement: "This study investigates the effects of pediatric aquatic therapy on motor function, enjoyment, activities of daily living, and health-related quality of life for children with spastic cerebral palsy of various motor severities." Research Question: How does 12 weeks of pediatric aquatic therapy effect motor function and the enjoyment of daily activities for children with spastic cerebral palsy.	Clinical Practice Setting: Departments of physical therapy in a pool with therapists and safety personal Sampling methods: Recruited from two tertiary hospitals from the departments of physical medicine and rehab. Sample size: 24 participants selected at random (11 in aquatic therapy group and 13 in the control group)	Design: Randomized control study Level of Evidence: 2	Findings: Aquatic therapy improved patient's 66-item Gross Motor Function Measure score by 4.7 points and on average the children treated with aquatic therapy had a higher level of enjoyment Conclusion: Pediatric aquatic therapy improved gross motor function and improved enjoyment of activity.	Practice & Research Implications: Aquatic therapy for pediatrics can improve their gross motor function and enjoyment in therapy providing a better quality of life. Therefore, this strengthens the research for the importance of aquatic therapy being incorporated into CP therapies. Additionally, this therapy can be used for participants with a poor gross motor function rating.	Limitations of Findings: limited sample size, participant characteristics, convenience sample size, and short intervention period

Retarekar, R., Fragala-Pinkham, M. A., & Townsend, E. L. (2009). Effects of Aquatic Aerobic Exercise for a Child with Cerebral Palsy: Single-Subject Design. *Pediatric Physical Therapy*,*21*(4), 336-344. doi:10.1097/pep.0b013e3181beb039	Purpose Statement: "The purpose of this study was to evaluate the effects of an aquatic aerobic exercise program for a child with cerebral palsy." (pg. 336) Research Question: How does a 12-week aquatic exercise program affect pediatrics with spastic diplegia?	Clinical Practice Setting: Franciscan Hospital Sampling methods: Selected and approved from Franciscan hospital Sample size: 1 five-year-old female classified as a level 3	Design: single descriptive Level of Evidence: 6	Findings: Improvements were found in all 3 areas that were measured. Conclusion: Aquatic therapy provided improvement of Gross Motor Function for type 3 severity of cerebral palsy	Practice & Research Implications: Aquatic therapy is a good resource for gross motor function. Therapy is feasible with pool access	Limitations of Findings: Small sample size
Robotic Gait Training						
Bayón, C., Martín-Lorenzo, T., Moral-Saiz, B., Ramírez, Ó., Pérez-Somarriba, Á., Lerma-Lara, S., … Rocon, E. (2018). A robot-based gait training therapy for pediatric population with cerebral palsy: goal setting, proposal and preliminary clinical implementation. *Journal Of Neuroengineering And Rehabilitation*, *15*(1), 69. https://doi-org.ezproxy.uakron.edu:2443/10.1186/s12984-018-0412-9	Purpose Statement: This study proposes a robotic gait training program for pediatric patients with cerebral palsy. Research Question: How effective is robotic gait training (CP Walker) on the pediatric cerebral palsy population with focus on strength, mean velocity, and gait performance?	Clinical Practice Setting: Hospital Infantil Universitario Nino Jesus, Spain. Sampling methods: Children 11-18, suffering from spastic diplegia, max 75 kg, Gross Motor Function level 1-4. Able to understand commands. Sample size: 4 two males two females	Design: Quasi-experimental design Level of Evidence: 4	Findings: Evaluations of patient improvements was done by comparing the patient to themselves rather than a control group. All patients improved in standing and walking categories. Conclusion: It was decided that the CPWalker is complementary to traditional therapy	Practice & Research Implications: This research contributes to the development of robotic treatment and can be implemented in patient treatment in combination with traditional therapy.	Limitations of Findings: no control group -Very small sample size -¾ patients only completed 15 out of 16 sessions.

				and can be used to better outcomes.		

Bayón, C., Ramírez, O., Velasco,M., Serrano, J.I., Lerma Lara, S., Martínez-Caballero, I., Rocon, E. Pilot study of a novel robotic platform for gait rehabilitation in children with cerebral palsy. (2016). *2016 6th IEEE International Conference on Biomedical Robotics and Biomechatronics (BioRob), Biomedical Robotics and Biomechatronics (BioRob), 2016 6th IEEE International Conference On*, 882. https://doi-org.ezproxy.uakron.edu:2443/10.1109/BIOROB.2016.7523739	Purpose Statement: This is a clinical pilot trial of a robotic gait system for balance and gait function restoration in children with cerebral palsy. Research Question: What effects does robotic gait therapy have on gait rehabilitation in children with cerebral palsy?	Clinical Practice Setting: Hospital Infantil Universitario Niño Jesús Sampling methods: Recruited from the facility Sample Size: 2 patients One classified as a level 2 and one as a level 3	Design: Quasi-experimental Design Level of Evidence: 4	Findings: the two children improved mean velocity, cadence and step length in each leg. Each case was reviewed individually. Conclusion: The experiment provided a new variable to change the difficulty of the tasks during the therapy. It is believed that this approach improved the outcome of the therapy by making it more attractive and challenge to the patient.	Practice & Research Implications: demonstrates the potential of robot-based technology in the rehabilitation of children with CP. More importantly, they also highlight the need to tailor the therapy to the particularities of each subject.	Limitations of Findings: small sample size Limited number of sessions

Lefmann, S., Russo, R., & Hillier, S. (2017). The effectiveness of robotic-assisted gait training for paediatric gait disorders: systematic review. *Journal Of Neuroengineering And Rehabilitation*, *14*(1), 1. https://doi-org.ezproxy.uakron.edu:2443/10.1186/s12984-016-0214-x	Purpose Statement: Identify and appraise the existing evidence for the effectiveness of robotic gait training for pediatric patients" (pg. 1) Research Question: Is robotic gait training an effective therapeutic treatment option for children with cerebral palsy?	Clinical Practice Setting: Sampling methods: Any clinical trial that evaluated a clinical aspect of robotic gait training in children . from year 1980-2016 Sample size: 17 clinical trials were evaluated years 2007-2016	Design: Systematic Review Level of Evidence: 1	Findings: Conclusion: Weak and inconsistent evidence to support the benefits of robotic gait training for pediatric patients with cerebral palsy.	Practice & Research Implications: Establishing how effective robotic gait training is over multiple studies. It has brought to attention that further testing is needed, and close monitoring of the patients is important within trials.	Limitations of Findings: Bias within evaluation of the research along with bias within the research Lack of sample size

van Hedel, H. J. A., Meyer-Heim, A., & Rüsch-Bohtz, C. (2016). Robot-assisted gait training might be beneficial for more severely affected children with cerebral palsy. *Developmental Neurorehabilitation*, *19*(6), 410–415. https://doi-org.ezproxy.uakron.edu:2443/10.3109/17518423.2015.1017661	Purpose Statement: investigate whether changes in walking outcomes using this therapy differs between levels of severity of cerebral palsy. Research Question: What walking related changes may occur between levels of Gross Motor Function Classification in children with cerebral palsy that undergo robotic gait training therapy?	Clinical Practice Setting: Rehabilitation Center Affoltern am Albis, University Children's Hospital Zurich, Switzerland. Sampling methods: Patient were recruited from the center's database. Excluded are patients who have severe lower extremity contractures, fractures, osseous instabilities, osteoporosis, severe disproportional bone growth, unhealed skin lesions, thromboembolic disease, cardiovascular instability, mechanical ventilation, severe cognitive deficits, and aggressive and self-harming behaviors. we excluded those who had changes in concomitant treatment 12 weeks prior study (e.g. botulinum toxin or orthopedic surgery)	Design: Random Control trial Level of Evidence: 2	Findings: Children with GMFCS level II did not improve significantly, found that especially the more affected children (GMFCS IV) profited more from RAGT. Significant improvements in the WeeFIM items transfer and walk, as well as the mobility and total WeeFIM scores, were found. Conclusion: results indicated that, although children with a GMFCS level IV walked less during an average Lokomat session, they experienced significant improvements in walking-related	Practice & Research Implications: Further training and investigation needs to occur to come up with best treatment within this therapy. Specifically, controlled studies would be most beneficial.	Limitations of Findings: patients received other therapies and treatment for individual needs Number of sessions was not held consistent for each patient -only able to retrieve information regarding the specifics of other concurrent therapies for 30 of 67 participants with CP

		and we excluded a small number of patients who had received Lokomat training only (p 411) Sample size: 67 children		outcomes. Further, training dose correlated with changes in walking-related outcomes.		

Wallard, L., Dietrich, G., Kerlirzin, Y., & Bredin, J. (2017). Robotic-assisted gait training improves walking abilities in diplegic children with cerebral palsy. *European Journal Of Paediatric Neurology: EJPN: Official Journal Of The European Paediatric Neurology Society*, *21*(3), 557–564. https://doi-org.ezproxy.uakron.edu:2443/10.1016/j.e	Purpose Statement: To focus on the effects robotic gait training has on balance control in children with cerebral palsy. Research Question: How effective is RAGT on full body movements in children with CP?	Clinical Practice Setting: recruited from the Unit of Clinical Movement Analysis of the Health Center Sampling methods: children with spastic diplegia and can walk with or without assistance. Sample size: 30 children ages 8-10 (fourteen received 20 sessions of RAGT, sixteen received daily physiotherapy) - randomly selected	Design: Random Control trial Level of Evidence: 2	Findings: Vicon system was used to evaluate total body movements. This method of evaluation eliminates bias from individual interpretation. The measurements evaluated the angles of the joints and compared before and after treatment. Significant differences for the upper and lower body but no significant findings for the thorax, pelvis, and hips. There were no significant differences in the data collected between the group that underwent interventions and the control group. Conclusion: Results from the research confirm that individuals can benefit from robotic gait rehabilitation and improve gait patterns.	Practice & Research Implications: This research adds to previous research and provides further information on robotic gait training. This allows for alternative methods of therapy for cerebral palsy patients with a focus on improving gait.	Limitations of Findings: Limited to one area Limited to children with spastic CP No long term follow up More in the control group The exoskeleton blocks hip and lower trunk mobility Cognitive abilities were not evaluated

Traditional Therapy						
Brandão M.B., Oliveira R.S., & Mancini, M.C. (2014). Functional priorities reported by parents of children with cerebral palsy: contribution to the pediatric rehabilitation process. *Brazilian Journal of Physical Therapy, 18* (6). Retrieved from https://doi-org.ezproxy.uakron.edu:2443/10.1590/bjpt-rbf.2014.0064	Purpose statement: To describe functional priorities established by caregivers of CP children by level of severity and age, and to assess changes on performance and satisfaction on functional priorities reported by caregivers, in 6-month interval	Clinical Practice Setting: Brazil Sample size: 75	Design: Descriptive study (questionnaire) Level of Evidence: 6	Findings: most importance was personal care such as feeding, dressing and hygiene. Functional mobility activities were not the main focus for the parents of these patients. The only age group in which mobility was the highest priority were in the 3-6 year age group	Practice Research: emphasizes the importance of collaboration with parents in the therapeutic process. Mobility is of most importance for ages 3-6.	Limitations of Findings: bias of parent preference, limited to the institution

Eliso, M. (2017). Effects of early regular physical therapy treatment on gross motor function of children with cerebral palsy. *Journal of Physical Education & Sport*, *17*(1), 284–287. Retrieved from http://ezproxy.uakron.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=s3h&AN=123822880&site=eds-live	Purpose: To analyze the effects of physical therapy on children with cerebral palsy starting at the ages of 4 months and 12 months. Research Question:	Setting: Physical Therapist (PT), Children's Neurodevelopment Centre, Georgian State Teaching University of Physical Education and Sport, GEORGIA Sampling Methods: Patients evaluated at the Neurodevelopmental center were recruited Sample Size: 16	Design: Randomized Control Trial Level of Evidence: 2	Finding: The results show that GFMF points were increased in case of every child patient, which highlight the effectiveness of physical exercises Conclusion: As the level of improvement in case of every child patient with cerebral palsy is individual. When applying the method of rehabilitation physical exercises as a treatment individual needs should be taken into consideration. It is essential to apply the method of gradual increase of regular physical exercises, for the purpose of the	Implications for practice: It is important for nurses to understand the effectiveness of interventions at early stage. As early as 4 months and for long term.	Limitations: Small sample size No control group Limited age range

				gross motor muscles function improvement		

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[1] As you complete your summarizing tables/TOE, be succinct, accurate, and summarize with your own words. Minimally use quotes, and IF you do, e.g., the purpose statement, use quotation marks and a page number to acknowledge quote. In the past, students have used quotes more in these tables, which doesn't reflect understanding as much as, maybe, copy and paste skills. It also makes these tables longer and more cumbersome.

[2] These are typically in introduction of publication and abstract. Construct a research question if it is not stated in article.

[3] Where did authors conduct study? How did they select subjects? How large was sample?

[4] What design did authors use? Look at Pyramid of Evidence (inside of back cover of textbook. Pyramid tip is Level I, RCT is Level 2, etc.

[5] How did data answer research question? What do authors conclude in the discussion section?

[6] What do the findings recommend about practice and future research?

[7]List limitations related to validity and reliability of methods and applicability of findings. Consider strengths and weaknesses of study, i.e., sample size, no randomized group assignment, no control/comparison group, tools lacking reliability and validity, no use of blinding, no power analysis/data saturation to determine sample size, no use of theory to guide study, threats to internal and external validity, etc.