2020

Preserving Shoulder Integrity for Pediatric Wheelchair Users

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***This resource was written by doctoral-level students in fulfillment of the requirements of the Occupational Therapy course "OT 403 - Clinical Research Methods in Occupational Therapy" at the University of North Dakota School of Medicine and Health Sciences, under the advisement of Professor/Course Director Anne Haskins, Ph.D., OTR/L, Assistant Professor Breann Lamborn, EdD, MPA, Professor Emeritus Gail Bass Ph.D., OTR/L, and Research and Education Librarian Devon Olson Lambert, MLIS.

Focused Question

What is the impact on preserving shoulder integrity with the use of manual versus power wheelchairs for children with spina bifida and other spinal cord injuries (SCIs) while they participate in daily occupations such as play, education, ADLs, and functional mobility (American Occupational Therapy Association [AOTA], 2014)?

Clinical Scenario

According to the Centers for Disease Control and Prevention (CDC) (2019), 1,645 babies are born with spina bifida each year. There are three different types of spina bifida, with myelomeningocele being the most common. As for prevalence, "Hispanic women have the highest rate of having a child affected by spina bifida, when compared with non-Hispanic white and non-Hispanic black women" (CDC, 2019, para. 2). Children diagnosed with spina bifida may face motor, sensory, and cognitive impairments that can affect their quality of life and participation in occupations. According to Murray et al. (2015), children between the ages of 8 and 15 with spina bifida reported lower health-related quality of life compared to other children with chronic health conditions, making children with spina bifida a population of great interest to occupational therapists. Furthermore, the lifetime cost of care for a person with spina bifida is $791,900 (CDC, 2019). According to the American Spinal Injury Association (ASIA) (2020), about 20% of SCIs occur in children and adolescents. Around 1,455 children are admitted to hospitals each year for treatment for SCIs in the United States (ASIA, 2020). The leading cause of pediatric SCIs are car accidents followed by falls. Males are also two times more likely to obtain a SCI than females (Chin, 2018).

Babies are typically diagnosed with spina bifida during pregnancy or when they are born, however, SCIs can occur during any stage of life (CDC, 2019). The health status of these individuals varies depending on the type of spina bifida or SCI that they have and where it occurs in the body. The environment becomes an important aspect to consider as participation in daily tasks may be supported or inhibited by using power or manual wheelchairs. For example, the use of a wheelchair may support accessibility and participation in play by allowing children to navigate in their environment. On the other hand, if the environment is not wheelchair accessible or if the child fatigues easily when using a manual wheelchair, engagement in play with others may be inhibited resulting in social isolation and occupational deprivation. Functional mobility is another area of concern when considering power versus manual wheelchairs, especially for adolescents as they start to desire independence from their parents. Additionally, repetitive and strenuous overuse of the shoulder joint during manual wheelchair use can lead to pain or injury, decreasing independence.

Play is an extremely important occupation for children. The CDC (2019) indicated that regular physical activity and play are important for all children, but even more so for those with conditions that affect movement such as spina bifida and other SCIs. While engaging in play, children must be able to mobilize themselves in order to interact with others. Children with spina bifida can mobilize themselves in numerous ways including walkers, crutches, braces, and using wheelchairs. With the use of these assistive devices, both mobility and play become more achievable. Education is also a major occupation that children participate in. Accessibility can be an issue depending on the location of both the school and the classroom, and the type of wheelchair that the student uses.

We used Winnie Dunn's Ecology of Human Performance (EHP) model to guide our research (Dunn, 2017). This model looks at the interaction between the person, context, and task in relation to performance range or the ability to perform tasks (Dunn, 2017). We believe that this model aligns with our research topic and will help us to better understand each of the components of our population. Furthermore, Dunn provides five intervention strategies through the EHP model for occupational therapists to utilize in practice (Dunn, 2017).

A critically appraised topic is necessary to help guide occupational therapists working with this population by providing a summary of the available research and a clinical bottom line for best practice. Our research will be used to address the focused question and to inform client education and third-party payers for reimbursement.

Summary of Key Findings

Our initial literature searches were conducted individually between February and April of 2020. Together we found 32 articles using CINAHL Complete and PubMed databases. Of these 32 articles, there were four articles that were duplicated between our group members; therefore, we had a total of 28 articles from our initial literature search. To locate our articles, we used ancestry search methods and Boolean search phrases that were a combination of the following key words, "wheelchairs, manual, power, children, pediatric, spina bifida, spinal cord injury, mobility, mobility devices, and shoulder pain." Our inclusion criteria consisted of children, adolescents, adults, spinal cord injury, spinal bifida, manual wheelchairs, power wheelchairs, mobility, shoulder integrity, and shoulder pain. Exclusion criteria included articles that were published over 20 years ago, individuals without spinal cord injuries or spina bifida, and individuals who do not use manual or power wheelchairs.

We then began to read the articles for relevancy and importance in order to answer our focused question. We eliminated articles that were unrelated to our topic and refined our search to include 17 articles with which we completed extensive literature critiques. We rated these 17 articles according to Lieberman and Scheer's (2002) levels of evidence classification system for occupational therapy. We had one Level II article (Sawatzky, Rushton, Denison, & McDonald, 2012), four Level III articles (Bottos, Bolcati, Sciuto, Ruggeri, & Feliciangeli, 2001; Kwarciak, Turner, Guo, & Richter, 2012; Rammer et al., 2019; Slavens et al., 2015), eight Level IV articles (Bickelhaupt et al., 2018; Boninger et al., 2002; Ferrero et al., 2015; Guerette, Tefft, & Furumasu, 2005; Roehrig & Like, 2008; Sawatzky, Slobogean, Reilly, Chambers, & Hol, 2005; Schottler, Graf, Kelly, & Vogel, 2019; Weinstein, Lloyd, Finch, & Laszacs, 2018), and four Level NA articles (Calhoun, Schottler, & Vogel, 2013; Krey, 2005; Ong, Wilson, & Henzel, 2020; Paralyzed Veterans of America Consortium for Spinal Cord Medicine [PVACSCM], 2005). Of the level NA articles, three were narratives with two on the topic of mobility; however, we only focused on the aspects related to wheelchair use and functional mobility (Calhoun et al., 2013; Krey, 2005). The third narrative was about educating health care professionals on proper care for people with SCIs, however we only focused on care for preserving shoulder integrity (Ong et al., 2020). The final level NA resource was a clinical practice guideline for health care professionals regarding preservation of upper extremity function for individuals with SCIs (PVACSCM, 2005). The methodology of this resource consisted of an extensive literature search much like that of a systematic review, however it was published in 2005, therefore it cannot be rated as rigorously for current use.

Manual Wheelchairs

Manual wheelchairs need to be fitted appropriately for the individual who will be operating them. Many authors have highlighted factors such as age, environment, context, developmental stage, and level of injury as details for practitioners to consider when making recommendations for different types of wheelchairs (Calhoun et al., 2013; Guerette et al., 2005). Manual wheelchair fittings are unique for the pediatric population because the wheelchair needs to allow for growth of the child over time. This can make fitting pediatric patients in wheelchairs challenging, especially since insurance will only cover the purchase of a new wheelchair every three to five years (Krey, 2005). According to Krey (2005), many clinicians are taught the *2 inch rule* which states that, “2 inches are added to the patient’s seat width and 2 inches are subtracted in the patient’s seat depth” (p. 86). In order for proper biomechanics and propulsion, the wheelchair axel should be positioned under the child’s pelvis to help distribute body weight evenly and the back of the seat should be high enough to provide necessary trunk control while still maintaining free movement of the scapula (Krey, 2005).

There are four different propulsion patterns to consider when using manual wheelchairs. They are classified as arcing, double loop (DL), semi-circular (SC), and single loop (SL) (Boninger et al., 2002; Kwarciak et al., 2012; Schottler et al., 2019). The semi-circular pattern is recommended to preserve shoulder integrity and reduce joint pain (Boninger et al., 2002). Kwarciak et al. (2012) completed a pretest-posttest study that involved 25 participants in order to investigate the most effective propulsion patterns. Participants were given two minutes to maneuver their wheelchair using their preferred technique. After initial observation, participants were randomly assigned one of the four propulsion patterns to use while on a wheelchair accessible treadmill following an acclimation period of three minutes. They found that the SC pattern produced the most favorable hand and shoulder biomechanics compared to that of the SL and arcing propulsion patterns (Kwarciak et al., 2012). On the other hand, a randomized control trial completed by Bickelhaupt and others in 2018 showed contradicting findings in that the SC propulsion pattern caused shoulder fatigue during long distance propulsion.

In 2019, a study conducted by Rammer et al. assessed the effects of occupational therapy and physical therapy by evaluating the biomechanics of pediatric manual wheelchair users who attended a seven-week camp. There were ten participants in the study including eight males and two females ages 6 to 17. Interventions included group therapy, individual intensive therapy, sports and recreational activities, and daily mobility used to get around the camp (Rammer et al., 2019). Participants in this study were evaluated at weeks one, four, and seven using a roller platform. A markerless wheelchair propulsion assessment system was used to map the child's propulsion patterns. A Shriners Hospital Upper Extremity Evaluation (SHUEE) was also performed, and the results showed that the interventions had broad effects on upper extremity functions (Rammer et al., 2019). Rammer et al. (2019) also evaluated the results of the propulsion maps and found that four of the youths' propulsion patterns did not suggest a change over time, while one had slight changes, and the remaining five participants had prominent changes in their propulsion patterns. These changes included an increase in the size of the propulsion pattern and a smoother semicircular propulsion pattern, further demonstrating how therapy can be used to teach appropriate biomechanics to help preserve shoulder integrity in youth (Rammer et al., 2019).

Shoulder Integrity

Although many individuals with SCIs and spina bifida use manual wheelchairs, it has been shown that manual wheelchair use over long periods of time may lead to shoulder pain or shoulder injury (Ferrero et al., 2015; PVACSCM, 2005; Sawatzky et al., 2005). Many authors have researched manual wheelchair use, shoulder integrity, and upper extremity preservation; however, these studies usually involve adult populations and the findings should not be assumed for the pediatric population (Krey, 2005; Rammer et al., 2019; Sawatzky et al., 2005; Slavens et al., 2019). Possible risk factors associated with shoulder pain for manual wheelchair users include age, level of SCI, joint overuse issues, and the amount of years spent using a manual wheelchair (Ferrero et al., 2015; Ong et al., 2020; Roehrig & Like, 2008; Sawatzky et al., 2005). Ferrero et al. (2015) performed a retrospective study involving 96 subjects who use manual wheelchairs and found a significant relationship between age and the onset of shoulder pain. Ferrero et al. also found that higher levels of SCI (T2-T7) are associated with more shoulder pain than lower level SCIs. Finally, individuals who sustained a SCI in adulthood reported shoulder pain from using a manual wheelchair sooner than those individuals who sustained a SCI at a younger age (Ferrero et al., 2015). Ferrero et al. proposed that this phenomenon could be because younger individuals' bodies are not fully matured, therefore they are able to adjust to the load and strain their joints endure. On the other hand, older individuals' bodies are already fully developed and do not adapt as well to the blunt force applied to their joints, resulting in pain or injury.

Sawatzky et al. (2005) also investigated the effects of shoulder pain in adult-onset manual wheelchair users versus childhood-onset users. Cross-sectional methods were used to study 53 subjects with SCIs. Childhood-onset wheelchair users were those who began using a manual wheelchair before age 16 and adult-onset users were those who began using a manual wheelchair after age 16. Shoulder pain and overall pain, as measured by the Wheelchair User's Shoulder Pain Index (WUSPI) and the Brief Pain Inventory (BPI) scales respectively, were significantly higher in the adult-onset wheelchair users than in the childhood-onset users (Sawatzky et al., 2005). This finding is congruent with the findings of Ferrero et al. and a similar explanation is provided regarding tissue remodeling in young wheelchair users with developing skeletal structures. Sawatzky et al. also proposed beneficial biomechanical and behavioral adaptations in the childhood-onset wheelchair users as potential reasons to explain this phenomenon.

Maintaining shoulder integrity is crucial to functional independence for individuals with SCIs or spina bifida (Roehrig & Like, 2008). Roehrig and Like (2008) completed a descriptive research study comparing shoulder pain in individuals with SCIs to individuals with spina bifida. They found that individuals with spina bifida reported less shoulder pain, as measured by the WUSPI, than individuals with SCIs (Roehrig & Like, 2008). On the other hand, upper limb injuries are extremely common for individuals with SCIs, with more than two-thirds of manual wheelchair users having reported shoulder pain or injury (Ferrero et al., 2015; Sawatzky et al., 2005). If shoulder function is lost due to injury or overuse, the individual will become dependent on others to help them complete transfers, activities of daily living (ADLs), and other functional daily tasks (Ong et al., 2020; PVACSCM, 2005). Ong et al. (2020) and the PVACSCM (2005) suggested that switching to a power wheelchair is an appropriate intervention approach to preserve shoulder integrity and promote independence in transfers and ADLs.

Power Wheelchairs

Before committing to a power wheelchair, one might want to consider power assist devices. Power assist devices can be mounted to manual wheelchairs, making them lighter, less expensive, and easier to transport than power wheelchairs (PVACSCM, 2005). Additionally, power assist devices may help to preserve energy and shoulder integrity for individuals who use manual wheelchairs. However, power assist devices are not a long-term solution and may not be suitable for some people. If powered mobility has been chosen as the best option, there are many different types of powered wheelchairs to consider with varying physical aspects. According to Calhoun et al. (2013), "there are 3 options for placement of the drive wheels on a power wheelchair: front, rear and mid or center wheel drive" (p. 143). In front drive wheelchairs the main wheel is located in front of most of the chair, whereas the wheels of center drive chairs are typically located underneath the seat of the individual who would be driving the chair. Rear wheel drive chairs, with the main wheel located in the back, are considered the most stable option under most circumstances, especially for terrain and power tilt mobility (Calhoun et al., 2013).

According to the literature, there are strong recommendations for children to start using powered mobility as early as possible (Sawatzky et al., 2012; Weinstein et al., 2018). The use of powered wheelchairs has been shown to have positive effects on an individual's cognitive, social, and perceptual skills, however powered mobility is usually not considered until upper limb injury or severe pain occurs (Bottos et al., 2001; PVACSCM, 2005). According to the PVACSCM (2005), the advantages of power wheelchairs include, "reduced propulsion-related repetitive strain, conserved energy and therefore reduced fatigue, increased speed, and increased ease of traversing on uneven terrain and inclines" (p. 448). Possible disadvantages of powered wheelchairs are, "decreased transportability, increased maintenance, increased cost, possible weight gain, and possible decreased fitness" (PVACSCM, 2005, p. 448). In a retrospective study with 29 participants, Bottos and others (2001) found that an individual's level of independence is much higher when using a powered wheelchair versus a manual wheelchair. Specifically, a statistically significant improvement in ADLs while using a powered wheelchair was found. In this same study, Bottos et al. (2001) found that motor impairment, IQ, and quality of life did not increase with powered mobility.

Many aspects need to be considered when deciding between manual versus power wheelchairs for children. Many children use manual wheelchairs for mobility due to the lower cost, insurance coverage, and feasibility. When doing so, the SC propulsion pattern is recommended for preserving shoulder integrity (Boninger et al., 2002; Kwarciak et al., 2012; Schottler et al., 2019). Better yet, powered wheelchairs are optimal for preserving shoulder integrity (Calhoun et al., 2005; PVACSCM, 2005; Weinstein et al., 2018). Overall, the type of wheelchair a child uses will greatly impact their shoulder integrity later in life and their participation in occupations such as play, ADLs, functional mobility, and education (AOTA, 2014).

Clinical Bottom Line

Many children with spinal cord injuries (SCIs) and spina bifida use wheelchairs as their source of mobility. The purpose of this critically appraised topic was to investigate the impact of manual versus power wheelchairs on preserving shoulder integrity for children with SCIs and spina bifida as they engage in meaningful occupations. There are many factors to consider when deciding between manual versus power wheelchairs, including insurance coverage, cost, feasibility, the individual’s context, and overall independence (Dunn, 2017). A thorough evaluation and wheelchair fitting process is completed, which may involve the client, occupational therapists, physical therapists, physicians, engineers, families, caregivers, insurance companies, and durable medical equipment sales representatives.

Children with spina bifida and SCIs rely heavily on their shoulder joints to complete transfers, ADLs, and participate in other meaningful occupations such as education and play (AOTA, 2014). Therefore, when their shoulder integrity is compromised due to pain or injury, it is detrimental to their independence (Ong et al., 2020; PVACSCM, 2005; Roehrig & Like, 2008). The use of manual wheelchairs over long periods of time can cause shoulder pain or injury, which is especially important to consider for children as they transition into adulthood (Ferrero et al., 2015; PVACSCM, 2005; Sawatzky et al., 2005). If an individual is using a manual wheelchair, it is recommended to use the semi-circular propulsion pattern for optimal shoulder biomechanics (Boninger et al., 2002; Kwarciak et al., 2012; Schottler et al., 2019).

In the literature reviewed, there was not sufficient evidence of shoulder pain reported by pediatric manual wheelchair users. However, more than two thirds of adults with SCIs reported shoulder pain from manual wheelchair use, which is why a proactive approach to preserve shoulder integrity in children is needed (Ferrero et al., 2015; Sawatzky et al., 2005). When looking to preserve shoulder integrity, power assist devices might be a good option to consider. Power assist devices can be mounted to a manual wheelchair, providing a lighter and occasionally less expensive option to bridge the gap between manual and power wheelchairs. Additionally, they are much easier to transport as compared to power wheelchairs and can function to preserve energy expenditure and shoulder integrity for individuals (PVACSCM, 2005). However, there are strong recommendations in the literature for children to start using powered mobility as early as possible (Sawatzky et al., 2012; Weinstein et al., 2018). Powered wheelchairs have been shown to cause less strain on the shoulder joints and promote independence in occupations (Calhoun et al., 2005; PVACSCM, 2005; Weinstein et al., 2018). A majority of the literature we reviewed was focused on adult populations, thus there is insufficient evidence regarding children and preservation of shoulder integrity during wheelchair use. Future research in the area of pediatric wheelchair use and shoulder preservation needs to be completed to enable evidence-based practice for occupational therapists.

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