RESNA Position on the Application of Ultralight Manual Wheelchairs

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Background

Since its beginning, the manual wheelchair industry has transitioned from wheeled devices that required the individual to adapt to fit the device, to an era when the device is designed to fit the individual and the individual's lifestyle. The first manual wheelchairs were essentially wooden chairs with wheels. In 1930s and 40s the X-frame folding wheelchair was developed by Herbert A. Everest and Harry C. Jennings. A design revolution occurred during the 1970s and 80s, which incorporated advances in wheelchair design and fabrication including decreasing the weight of the wheelchair, increasing the maneuverability and decreasing the wear and tear on individuals using the wheelchair. The most recent advancements in the 1990s and 2000s are in the manufacturing sector, which allows individuals who utilize a wheelchair, to obtain a wheelchair customized to match her/his specific anatomical dimensions, provide mobility in her/his unique environment, and to perform a wide range of activities.[1-3]

A range of manual wheelchairs is currently available with features that vary in frame design and configuration, weight, durability, adjustability, customization, and accessories. These features can be customized to meet the intended use of the wheelchair and the expected lifespan of the wheelchair. The ideal manual wheelchair is as light as possible, durable for long-term continuous use, and custom-configured to meet the specific mobility and postural needs of the intended user.

It is RESNA's position that fully customizable manual wheelchairs that are as light as possible, durable for long-term continuous use, have customizable rear wheel and caster wheel location and configuration, and customizable seating configuration are the only acceptable option for individuals who rely on manual wheelchairs for independent manual mobility. Currently, these wheelchairs are typically identified as ultralight manual wheelchairs. The purpose of this document is to provide external evidence, as part of the evidence-based practice, which include rehabilitation and engineering principles to support the appropriate application of fully customizable manual wheelchairs.

Whenever possible this paper uses terminology from the RESNA standard for Wheelchairs – Volume 1: Requirements and Test Methods for Wheelchairs (including Scooters) – Section 26: Vocabulary.[4]

The purpose of this document is to share typical clinical applications as well as provide evidence from the literature supporting the application of this Assistive Technology intervention, to assist practitioners in decision-making and justification. It is not intended to replace clinical judgment related to specific client needs.

Scope:
For the purposes of this document, an ultralight manual wheelchair (ULWC) is defined as a fully customizable (adjustable and/or configurable) wheelchair that is as light as possible, is designed as an individual's primary mobility device and does not include features such as tilt or recline. Depending on the source, an ultralight wheelchair has been defined as less than 30 lbs.[5], (13.61 kg).[6] or less than 25 lbs. (11.34 kg).[2] Given the intent of this document as a guide for application as opposed to design, a specific product weight cut-off will not be utilized to define the recommendations made in this position paper. Currently, numerous wheelchairs weigh less than 20 lbs. (9.07 kg). Further weight reduction is anticipated as technology continues to advance.

The weight of an ULWC depends on numerous features incorporated into the overall design of the wheelchair, and includes seating as well as any other accessories added. These additional features and accessories, often incorporated into the seating system (seat cushion and back support), are necessary to meet the unique postural support requirements of the individual with a disability. Consequently, the final overall weight of the system (wheelchair, seat cushion, back support and postural supports) may vary. Therefore, the focus of this document is on wheelchairs that are as light as possible.

Ergonomics
The most appropriate manual wheelchair for individuals with disabilities who will utilize the wheelchair for an extended period is a properly configured, fully customizable wheelchair of the lightest weight possible. Ergonomic principles require that the device match the individual given a specific level of ability, environment and activity. Therefore, the appropriate manual wheelchair must have characteristic features that can be specified to match the anatomical dimensions of the individual as well as the individual's functional ability. That is, the person cannot conform to the wheelchair, but the wheelchair must conform to the individual. The principles of user-centered design[7] and universal design[8] prescribe to this fact. To meet these principles, a manual wheelchair must, at a minimum, have the following features set to specific measurements and/or positions for each individual at the time of acquisition.

Wheelchair Features [9], [10], [11], [12], [13]

- Seat surface height at front edge
- Seat surface height at rear edge
- Seat plane angle
- Seat width
- Seat depth
- Back support height
- Seat to back support angle
- Foot support to seat length
- Leg to seat surface angle
- Horizontal and vertical position of rear wheel axle
- Rear wheel camber
- Wheel type and size

- Caster type and size

The features of a manual wheelchair will significantly affect the performance of the wheelchair in terms of postural support, wheelchair stability, wheelchair maneuverability, and ease of propulsion. Numerous authors have addressed the affect of these features on the wheelchair's functional characteristics.[14-18] A guide to the measurement of wheelchair dimensions can be found in Chapter 2 of "Wheelchair Selection and Configuration"[13], online at the Greater Metropolitan Clinical Taskforce (GMCT) NSW State Spinal Cord Injury Service (SSCIS) education website for seating and wheeled mobility[19], or via the RESNA Standards[20].

Functional Characteristics [9], [10], [11], [12], [13]

- Rolling Resistances
- Downhill Turning Tendency
- Yaw Axis Control (i.e. ease of turning, maneuverability)
- Pitch Axis Control (i.e. traversing obstacles)
- Propulsion Efficiency
- Static Stability
- Transportability
- Footprint

Effect of a Highly Customizable Wheelchair on Functional Characteristics

SEAT TO FLOOR HEIGHT

The seat surface height at front edge is necessary to match the anatomical dimensions of the lower leg in conjunction with the foot support length as well as assure accessibility. An appropriate height will also accommodate the wheelchair cushion required by the individual. An appropriate seat surface height at the front edge provides proper support of both the lower leg and the thighs within the seating system. The seat surface height at rear edge is necessary for appropriate access to the handrim and postural support of the thighs relative to the seat surface height at front edge. Many individuals with impaired trunk control benefit from having the front seat height higher than the rear to provide increased support for stability... The seat surface height for both the front and rear are important for clearance under tables, footplate clearance over thresholds and facilitating transfers.

SEAT PLANE ANGLE

The seat plane angle (aka seat slope) is important in properly supporting the thighs, and minimizing the seat surface friction necessary to maintain an individual's position within the frame. Increased seat plane angle can reduce the individual's tendency to slide out of the wheelchair as long as the individual has sufficient range of motion at the hips and knees. Conversely, increasing the seat plane angle can make transfers more difficult.

SEAT WIDTH

Achieving seat width is critical in postural support and propulsion efficiency. In terms of postural support, if the seat width is too narrow it causes tissue compression by the clothing guards or armrests, which may cause a pressure ulcer to develop. If clothing guards or armrests are not present, then the individual's tissue can interfere with the wheels, causing scrapes and other shear related injuries. If the seat width is larger than necessary, the handrims will be difficult to access[10], placing the upper extremities in potentially injurious positions. Specifically, increased wrist flexion and shoulder abduction can lead to long term secondary injuries at the joints.[21] In addition, it may limit the individual's access to the environment by being too wide to maneuver through some doorways as well as decreasing overall ease of maneuverability and propulsion.

SEAT DEPTH

Proper seat depth is critical to providing appropriate postural support and proper weight distribution over the base. The seat depth not only affects the length of the support surface, but also the overall length of the wheelchair frame. A seat depth that is too short does not provide adequate surface for pressure redistribution nor appropriate postural support of the thighs and buttocks. An inadequate surface for pressure redistribution will lead to pain and discomfort. A short seat depth increases the load that must be supported by the buttocks, thereby increasing the risk for developing pressure ulcers under the sacrum and/or ischial tuberosities. A short seat depth also shortens the frame length, which increases the percentage of weight carried by the casters. The goal is to maximize the weight on the rear wheels to increase propulsion efficiency and maneuverability (ease of turning and ease of getting over obstacles such as door thresholds).

A seat depth that is too long will interfere with the proper support of the lower extremities. One potential consequence is that the individual could develop pressure sores at the popliteal fossa. A more harmful potential consequence is that the individual will slide forward to clear the front edge of the seat. This causes multiple problems. It may cause the individual to slide forward in the seat, increasing the posterior pelvic tilt and placing undue loading on the sacrum potentially producing a pressure sore. Prolonged sitting in this position can lead to muscle tightness and postural asymmetries, such as kyphosis, forward head, and rounded shoulders. Inducing a posterior pelvic tilt will also place the individual in a mechanically disadvantaged position for propulsion, making access to the handrims more difficult. Finally, there is also the possibility that the individual could slide out the front of the wheelchair.

BACK SUPPORT HEIGHT

Proper back support height is important for providing appropriate postural support of the posterior pelvis and the trunk for stability, as well as facilitating upper extremity function. If the back support height is too high it could limit scapular excursion and gleno-humeral range during upper extremity movement, thereby impairing upper extremity range of motion required for efficient propulsion. This leads to decreased maneuverability and pitch access control. If the back support height is too low, there is not adequate back support, resulting in trunk instability. This could make it very difficult for the individual to use their upper extremities to propel the wheelchair. Instead, the individual will use his/her upper extremities to maintain their balance. Some individuals with too low of a back support may slide forward in their seat to gain stability, resulting in the short seat depth concerns previously noted. Too low of back support can also result in the development or worsening of postural deformities due to inadequate trunk support.

SEAT TO BACK SUPPORT ANGLE

The seat to back support angle is important to assure proper positioning in the wheelchair for propulsion. A seat to back support angle of less than 90 degrees will "lock" the pelvis into a neutral or anterior pelvic tilt , creating a stable postural base. However, if the seat to back support angle is too small for an individual given their hip flexion range of motion they may not fit into the seating system. This will cause them to slide forward in the system to take pressure off of the hip and/or back. A seat to back support angle greater than 90 degrees can improve sitting balance for some individuals with decreased trunk control. Individuals with postural asymmetries such as a posteriorly tilted pelvis or kyphosis will often require a seat to back angle greater than 90 degrees to accommodate their posture. A seat to back support angle that is too large may promote a posterior pelvic tilt and kyphotic trunk posture and will change the line of sight upward.

FOOT SUPPORT TO SEAT LENGTH

The foot support to seat length (aka legrest length) is important for providing appropriate postural support to the lower extremities. If the length is too short, it can raise the knees and cause potential interference issues with objects (e.g. tables) in the environment. This will also inhibit proper pressure re-distribution, concentrating pressure at the ischial tuberosities and sacrum, leading to the possible development of pressure wounds. Furthermore, raised knees will reduce the effectiveness of the seating system since the thighs will not be properly supported by the front half of the seat cushion. Depending on the individual's hip flexion range-of-motion, raising the knees may cause a posterior pelvic tilt, which has significant implications in the potential development of pressure ulcers at, the ischial tuberosities, and the sacrum. Alternatively, if the foot support to seat length is too long the feet will not be properly supported, which may decrease sitting balance. A person may slide forward in the seating system – leading to lack of adequate postural support for mobility and function. The feet may also have a tendency to fall off of the footplates putting them at risk for dragging on the floor or interfering with the casters. Furthermore, if the length is too long, then the footplates may interfere with ground clearance, floor making it impossible to traverse thresholds, ramps, curbs and other uneven surfaces.

LEG TO SEAT SURFACE ANGLE

The leg to seat surface angle is important for providing appropriate postural support to the lower extremities. If the angle does not match the available passive range of motion of the knee for the individual, it has the potential to cause the person to slide out of the wheelchair or cause pressure ulcers on the posterior aspect of the calves. Furthermore, the leg to seat surface angle has a significant effect on the overall height and depth of the legrest as part of the overall wheelchair footprint.

POSITION OF THE REAR WHEEL AXLE

The horizontal and vertical position of the rear wheel axle has a significant impact on all of the functional characteristics of the wheelchair including stability, weight distribution, and turning radius, as well as the individual's propulsion style, propulsion efficiency, and access to the environment. Due to the impact on an individual's ability to gain access to her/his environment and potential physical harm from improper placement, all manual wheelchairs designed for long-term usage, must have the option to specifically prescribe the placement of the rear wheel axle, either at the time that the wheelchair is ordered from the manufacturer, or during the implementation process.

With regard to the horizontal position of the rear wheel axle, if it is too far rearward the chair will be more stable, but an individual will have to place his/her upper extremities in a less efficient and potentially injurious position[22 23] to access the handrim during propulsion. Moving the axle rearward increases the rolling resistance, making the chair harder to propel, by placing a larger percentage of the weight on the casters, requiring the user to work harder to propel the chair. Moving the axle rearward also increases the forces necessary to turn the wheelchair, and the effort required to maintain a straight line of travel when on a side slope. Moving the axle too far rearward makes it more difficult to de-weight the casters to perform a transitory wheelie, which is necessary to traverse obstacles. Finally, moving the axle too far rearward increases the turning radius and length of the wheelchair footprint, making it difficult to maneuver in tight spaces.

If the axle is too far forward then the rearward stability of the wheelchair may be compromised. This can increase the risk of the chair tipping over backward causing injury or harm to the user. Best practice is to position the axle as far forward as possible without compromising rearward stability or interfering with the casters.

When considering the vertical position of the rear wheel axle, if it is too high or too low then the individual will have a difficult time accessing the handrim for effective / efficient propulsion and this may place the upper extremities in a potentially injurious position. Furthermore, if the vertical position is not set appropriately for individuals who propel the wheelchair with their lower extremities, they will not be able to propel the wheelchair. Finally, the vertical position affects the rear seat to floor height and the seat angle, which have been discussed previously.

REAR WHEEL CAMBER

Choosing the correct camber angle for the rear wheels, can be critical to providing appropriate lateral stability and promoting responsiveness with efficient propulsion. Adding camber will widen the base of the chair for increased lateral stability, as well as bring the top of wheels closer to the user for an efficient push. For some users, when there is no camber (0 degrees) or minimal camber (1-2 degrees), lateral wheelchair stability is affected and they may have difficulty maintaining an upright position, when performing tasks that require leaning outside the footprint of the wheelchair. If the degree of camber is too large, then the individual may have difficulty maneuvering through doors, as this will increase the width of the wheelchair.

WHEEL TYPE AND SIZE

In terms of wheel type and size, the wheels are important to minimize the rolling resistance, decrease the weight and increase the reliability of the system. A larger diameter wheel has a lower rolling resistance, however if the wheel is too large then the seat-to-floor height may be compromised and access to the handrims may be compromised. Furthermore, the larger diameter tire may interfere with the caster, and will increase the length of the wheelchair footprint. A pneumatic tire should be considered as, when properly inflated, they typically have a significantly lower rolling resistance than solid tires or pneumatic tires with flat-free inserts. Non-pneumatic tires should be considered when the environment dictates that a flat-tire is a safety issue.

CASTER TYPE AND SIZE

In terms of the caster type and size, including the caster trail, the casters are important for stability, rolling resistance, and maneuverability. If the casters are too large, then they may interfere with the footrests and the rear wheels, and will affect the seat-to-floor height and seat angle. If they are too small and an individual is unable to perform a partial or full wheelie[24], then the person may not be able to traverse obstacles or rough terrain. Large caster forks create a larger caster trail than smaller forks. If the caster trail is too long then the caster wheel may interfere with the footplate and/or the rear wheel. A short caster trail will increase maneuverability but potentially compromise forward static stability when the casters are in a leading orientation.

Propulsion Biomechanics and Wheelchair Skills Acquisition:

The customizable features of ULWCs allow a practitioner to optimally match the wheelchair geometry to the end user's current and future needs. By selecting and correctly configuring a ULWC, the end user is able to propel more effectively. For example, the ability to select an appropriate seat height and wheelchair geometry contributes to seated stability, postural support, and the ability to transfer independently to surfaces such as a bed, car, and bathroom equipment.

ULWCs specifically address upper extremity pain and injury based on the following evidence:

- A more forward axle position decreases rolling resistance and therefore increases propulsion efficiency.[16]
- A forward placement of the rear axle decreases turning radius, downhill turning tendency and caster flutter.[25]
- A more forward axle position has been found to increase the hand contact angle or amount of the pushrim used by the individual.[26] It is also associated with less muscle effort, smoother joint excursions and lower stroke frequencies.[16]
- A lower seat position or a higher rear axle improves push biomechanics. A lower seat position has been associated with greater upper limb motions, greater hand contact angles, lower frequency and higher mechanical efficiency.[25-27]
- Customized wheelchair configuration that allows the wheelchair to act as an orthotic device provides necessary postural support that is critical for optimal function.[28] The adjustable and/or selectable features inherent to the ultra lightweight wheelchairs are required to provide individualized postural support.
- A forward placement of the rear axle shifts the wheelchair user's center of gravity closer to the center of rear wheel rotation, which increases the user's ability to

perform the wheelie skill.[29] Wheelies can be used to prevent or reduce impairments, and are the foundation of many other key skills. By simply tilting backwards, sitting pressures can be reduced, overhead objects can be viewed without extending the neck, and the incidence of injury can be reduced. The most valuable application of this skill involves navigating rough ground, curbs, and other obstacles as well as increasing user participation.[30]

- Pediatric wheelchair users can propel longer distances independently when using ULWCs as compared to lightweight wheelchairs. Their parents are also more satisfied when using ULWCs when compared to lightweight wheelchairs.[31]

Upper Extremity Pain and Injury

Manual wheelchair users experience a high incidence of upper extremity pain and dysfunction. The incidence of carpal tunnel syndrome (CTS) in manual wheelchair users is between 49-73%[32-35] while pain has been reported in up to 59% of individuals with spinal cord injury (SCI) and becomes more prevalent as the number of years using manual mobility increases.[36, 37] These orthopedic upper extremity injuries, including CTS and rotator cuff problems result in the need for costly medical interventions, loss of function and diminished ability to independently perform activities of daily living (ADL).[38] Pain has been correlated with lower quality of life scores. It has been identified as a major reason for decline of function in individuals with SCI who require more assistance since initial injury, resulting in increased dependence on personal care assistants and limitations to independence.[39-42] Upper limb pain and injury also causes disruptions in work, educational and social activities, which further contributes to impaired quality of life. Chronic upper extremity pain may ultimately direct a transition to a more costly powered wheelchair.

Due to the high incidence of upper limb pain and injury in individuals with spinal cord injuries, numerous researchers have investigated these issues. Two documents that summarize the information in this area and provide clinical recommendations are "*Preservation of Upper Limb Function Following Spinal Cord Injury: A Clinical Practice Guideline for Healthcare Professionals.*"[43] and *"Pushrim biomechanics and injury prevention in spinal cord injury: Recommendations based on CULP-SCI investigations"*[44]. The clinical practice guideline (CPG) document was formulated by 10 expert panel members and was reviewed by 38 additional experts. Several of the recommendations put forth in these clinical guidelines can be specifically applied to wheelchair provision with respect to prevention of upper limb pain and injury. Following the publication of this guideline, which references articles prior to 2004, Boninger, Koontz, et al. (2005) [44] published their recommendations that reinforce the clinical practice guideline. Although both documents are written for the population of individuals with spinal cord injury, the information has universal application to anyone who utilizes a manual wheelchair for her/his primary mode of mobility. Finally, Berner, DiGiovine and Roesler provided an update on the evidence from when the CPG was published in 2003, generating a review of the wheelchair literature based on the recommendations listed in the CPG. The update focused on the categories of ergonomics, equipment selection, training and environmental adaptations.[45]

With respect to a highly adjustable and configurable wheelchair that is lightweight the summary of recommendations within these two documents focus on three areas: Ergonomics, Equipment Selection, and Training.

The ergonomic recommendations include minimizing the stroke frequency, minimizing the forces generated during propulsion and minimizing extreme or potentially injurious positions. The appropriate set-up and configuration of an ultralight wheelchair directly addresses these three recommendations. The recommendations have been supported in the literature by numerous researchers.[38, 46-56]

The equipment selection recommendations include "providing a high-strength, fully customizable manual wheelchair made of the lightest possible material", "adjusting the rear axle as far forward as possible without compromising stability", and "placing the rear axle so that when the hand is placed at the top dead-center position on the pushrim, the angle between the upper arm and forearm is between 100 and 120 degrees". The recommendations have been supported in the literature by numerous researchers.[31, 57-70]

Finally, the training recommendations include using long, smooth strokes in a semi-circular pattern, and promoting appropriate seated posture and stabilization. Once again the appropriate set-up and configuration of an ultralight wheelchair, specifically the vertical and horizontal placement of the rear wheel, directly addresses an individual's ability to use long smooth semi-circular strokes. The set-up of the wheelchair, as this is the foundation of the seating system, regardless of the seat cushion and back support, is critical to promoting an appropriate seated posture and stabilization. These recommendations have been supported in the literature by numerous researchers.[71-73]

Other types of wheelchairs cannot safely and effectively address the recommendations for ergonomics, equipment selection and training because they are not adjustable to meet the unique anthropometric dimensions, postural requirements, and functional abilities of the individual. The significantly lower weight of ULWC's (some weigh less than 15 pounds) and the selectable components and configurations, can decrease the risk of repetitive strain injuries by limiting forces at the wrist and shoulder during wheelchair propulsion.[15, 16, 36] The risk of upper limb injury is also minimized when the individual is managing the wheelchair, as in the case of stowing the wheelchair in a vehicle.

ULWC's specifically address upper extremity pain and injury as supported by the following research evidence:

- ULWC's have reduced rolling resistance due to decreased weight, higher quality components (e.g. tires, wheels, bearings) and proper set-up of the wheelchair, which correlates to less force needed at the wrist to initiate and continue propulsion.[36 15, 16]
- Individuals using lighter wheelchairs push faster, travel further and use less energy, which means less fatigue during the day and over time. In older adults

using wheelchairs who do not have spinal cord injuries, the decreased weight also results in improved velocity, increased stroke length and decreased resultant and tangential force.[74, 75] Decreased wheelchair weight also results in a decrease in push frequency.[25, 76]

- An adjustable axle position is critical to ensure proper position of the wheels for maximum propulsion efficiency.[29] In tetraplegics, the further forward and higher up the axle is placed results in improved ability begin propelling their chairs. [77]
- A lower seat position gives better access to the wheels. It correlates with better upper extremity motion and lower push frequency. However, this position can be too low as the ideal angle is between 100 and 120 degrees of elbow flexion when the hand is placed on the pushrim.[25, 27]
- An ULWC requires less upper extremity force to independently load in and out of a vehicle.

Durability and Cost Effectiveness:
Stakeholders are constantly demanding that equipment last longer and provide functional benefits in a variety of settings. The materials used to fabricate ULWC's have high strength to weight ratios. Examples include aerospace grade aluminum, chromoly steel and titanium. They are therefore more durable, last longer, and resistant to fatigue and corrosion. Increased durability helps to ensure that the end user will get longer use from the ULWC with less need for costly repairs or replacements.

ULWC's have been proven to be the most durable and cost effective manual wheelchair option according to the following evidence:

- ULWC's have been shown to last 13.2 times longer than standard manual wheelchairs and to cost about 3.5 times less to operate.[78]
- In comparison to lightweight wheelchairs, which weigh 34-36 pounds as defined by Medicare, the ULWC's lasted 4.8 times longer and were 2.3 times less expensive to operate.[79, 80] When tested to failure, ULWC's had the longest survival rate and fewer catastrophic failures than both standard and lightweight wheelchairs.[81]

Summary:

- An ULWC is a highly adjustable and configurable wheelchair that is as light as possible to meet the unique requirements of the individual today and in the future
- Safe and functional manual wheelchair propulsion requires properly configured equipment. All stakeholders must consider the characteristics of the human, the activity, the assistive technology and the context (HAAT model).[82] The Clinical Practice Guidelines, in conjunction with the current peer-reviewed articles, recommend a fully customizable wheelchair made of the lightest high-strength materials. The evidence concerning upper extremity pain and injury in the population of manual wheelchair users suggests that the proper selection and configuration of ULWC's can significantly reduce the secondary complications associated with overuse syndromes. These include, but are not limited to, pain in the upper extremity, loss of independent function, the costs associated with loss of

work, social isolation and depression, the need to transition to more expensive power mobility, and costly surgical interventions.

- The evidence available regarding ultra-light manual wheelchairs suggests that a properly configured ULWC will contribute to long-term functional success, decreased incidence of secondary complications, and will cost less to maintain over time. An ULWC should be considered for all individuals who are manually propelling a wheelchair to ensure maximum function and safety.
- In consideration of an individual's anatomic and postural requirements, her/his activities, and the context for utilization, we recommend an ultralight manual wheelchair for individuals who utilize a wheelchair as her/his primary mode of mobility.

Case One:

Mr. Simmons is a 45-year-old father of two young children. He sustained a complete T8 spinal cord injury (SCI) ASIA A as a result of a motor vehicle accident. Prior to his injury he had no medical issues and was very active and healthy. He returned home from his inpatient rehabilitation and was able to resume his active lifestyle. He uses a manual wheelchair as his only means of mobility. Mr. Simmons works full-time outside of the home and is the primary caregiver for his two children. He drives a car and is required to complete several transfers in and out of his car daily. His current equipment includes a standard wheelchair with sling upholstery and appropriate seating.

In the past two years, Mr. Simmons has experienced increase pain in his right shoulder and bilateral wrists that limit his ability to perform tasks such as transfers and reaching overhead. He has found that by the end of the day he has difficulty completing is home management and childcare needs as his arms are sore and he has difficulty propelling. He currently skips activities he would participate in because of the discomfort in his shoulders. These limitations impact his ability to complete instrumental activities of daily living (IADL's) including cooking, shopping, and other tasks related to care of his children. Mr. Simmons reports that he fatigues easily throughout the day and needs to transfer out of his chair for extended "rest periods".

Mr. Simmons' wheelchair needed repeated repairs so it was suggested that he pursue a new frame. He went to the local seating clinic to get an evaluation where he was shown many styles of frames available. He participated in musculoskeletal exams to identify the cause of his pain and it was determined that the set up of his chair and the propulsion method he used were inadequate. He evaluated equipment and completed a propulsion analysis and several wheelchair skills tests.

After trial with an ultralight wheelchair with rear wheel axle adjusted appropriately for efficient propulsion, Mr. Simmons reported a decrease in upper extremity pain and fatigue. The custom fit of the new frame allows for improved seated stability and postural control during completion of his daily ADL's. As he experienced, these results were not achievable with a standard wheelchair. The use of an ultra lightweight manual wheelchair has had a significant impact on Mr. Simmons' ability to function independently and maintain a high quality of life.

After he received his chair and participated in adjustments with the seating clinic team he began applying the principles he learned along with the set up of his new frame. The data gathered from his follow up outcomes assessment indicated that his pain in his shoulders was significantly reduced and that he no longer had any disruption in accessing his environment to carry out the activities he needed and wanted to do.

Case Two:

Joshua is a 5-year-old who is a functional C6 quadriplegic due to Transverse Myelitis at two years of age. He is very motivated to be independent, play sports, and do all activities of a child his age.

Joshua's current wheelchair is a lightweight wheelchair with a significant amount of postural support devices (e.g. lateral trunk supports, lateral upper leg support and medial upper leg support) and a poorly adjusted center of gravity. The weight of the postural support devices and lightweight wheelchair weigh as much as Joshua. Previously, he had an ultralight wheelchair and had only gotten a new one due to his growth. Since receiving this wheelchair, he and his parents report that he cannot propel independently throughout the day due to fatigue.

After a trial of a properly adjusted ultralight wheelchair with lighter weight postural support devices that together were over ten pounds lighter than his current wheelchair set-up, it was determined that Joshua could be more independent and functional with this type of equipment. Consequently, he was provided with an ultralight wheelchair with appropriate positioning equipment. At delivery, the wheelchair was adjusted properly to him to maximize his propulsion ability.

Since the new wheelchair was provided to him, his mother reports that he is independent throughout the day and that he is now participating in wheelchair sports. He and his mother report that his quality of life has improved significantly as a result of the new properly configured ultralight wheelchair.

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RESNA, the Rehabilitation Engineering and Assistive Technology Society of North America, is the premier professional organization dedicated to promoting the health and well-being of people with disabilities through increasing access to technology solutions. RESNA advances the field by offering certification, continuing education, and professional development; developing assistive technology standards; promoting research and public policy; and sponsoring forums for the exchange of information and ideas to meet the needs of our multidisciplinary constituency.

Developed through RESNA's Special Interest Group in Seating and Wheeled Mobility

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