Rehabilitation Engineering and Assistive Technology Society of North America

RESNA Position on the Application of Tilt, Recline, and Elevating Legrests for Wheelchairs Literature Update

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RESNA Position on the Application of Tilt, Recline, and Elevating Legrests for Wheelchairs: 2015 Current State of the Literature

I. Introduction

The purpose of this document is to share typical clinical applications as well as provide evidence from the literature supporting the application of seat functions to assist practitioners in decision-making and justification. It is not intended to replace clinical judgment related to specific client needs. A RESNA Position Paper is an official statement by RESNA. Position Papers are not intended to be formal, scientific meta-analyses. Rather, they use evidence and expert advice to summarize best practices for Assistive Technology (AT) devices, evaluation, and service delivery. Position Papers provide a rationale for decision-making and professional skills for practitioners; and explain the medical or functional necessity of AT devices and services for policy makers and funding sources.

II. Statement of Position

A. The Position:

Tilt, recline, and elevating legrests are features that can be operated manually or as power options that can be added to wheelchairs. The beneficial effects of these seat functions have been reported as a clinical consensus statement in prior work (Dicianno et al., 2009). The purpose of this manuscript is to update this RESNA Position on the application of tilt, recline, and elevating legrests with more current and additional scientific literature.

It is RESNA's position that these features are often medically necessary, as they enable certain individuals to:

- Realign posture and enhance function
- Enhance visual orientation, speech, alertness, and arousal
- Improve physiological processes such as orthostatic hypotension, respiration, and bowel and bladder function
- Improve transfer biomechanics
- Regulate spasticity
- Accommodate and prevent contractures and orthopedic deformities
- Manage edema
- Redistribute and relieve pressure
- Increase seating tolerance and comfort
- Independently change position to allow dynamic movement

Special precautions must be exercised when utilizing these features in order to avoid the risk of injury, such as shear wounds. A licensed medical professional (i.e. physical or occupational therapist) must be involved with the assessment, prescription, trials and training in the use of the equipment and a specialty certified professional is recommended.

B. Populations and Subpopulations Affected

Those who may benefit from recommendations in this position are potential or current users of tilt, recline, or elevating legrests as manual or power functions. Those who are precluded from using these seat features would not benefit from the recommendations.

C. Contraindications

Contraindications to the use of each particular seat feature are listed in the original Position Paper (Dicianno et al., 2009) but include such considerations as using caution with tilt as it can cause backflow of urine with indwelling catheters, with recline as it can cause shear, with angles of elevating legrests to prevent reflex spasticity that may occur when extending the knee to end range, and with closing seat to back angle such that it puts stress on the hip joints.

III. Relevance of Position

A. RESNA and Constituencies

This paper may have implications on various RESNA related activities and could be used in several ways. First, it could serve as a guide to practitioners in the development and provision of seat functions. Second, it could be used as a tool in academia to guide education in AT-related knowledge and skills. Third, it could be used as a clinical teaching tool for educating clients or other team members. Fourth, it could be used as a source of support material when justifying seat functions and advocacy to obtain funding. Fifth, it could be used as evidence in organized educational efforts for policy changes or role definition. Finally, it could be used as a contribution to the development of a professional standard of practice.

B. Significance to Society

This paper may also have implications on society, including end users of AT. It could be used to guide education to consumers about the uses of seat functions to improve their general knowledge and ability to self-advocate.

IV. Rationale for the Position

A. Definitions

Tilt systems allow clients to change their seat angle orientation in relation to the ground while maintaining a constant seat to back angle and seat to legrest angle.

Traditional tilt operates in the sagittal plane. Most tilt systems tilt posteriorly in this plane, but some systems offer anterior tilt. Other tilt systems such as rotational and lateral tilt operate in coronal or oblique planes.

Recline allows clients to change seat to back angle and maintain constant seat angle with respect to the ground.

Elevating legrests allow clients to change the leg and/or footrest angle relative to the seat in order to flex or extend the knee. Some legrests articulate, that is, lengthen while extending the knee.

The scientific literature cited here supporting these features on wheelchairs has been drawn from research conducted with wheelchairs and ergonomic chairs, and also in participants with and without disabilities.

B. Overview of the Current Literature

Overview of Seat Function Use

Power wheelchair users with complex seating and rehabilitation needs, such as those with amyotrophic lateral sclerosis (ALS), rate tilt, recline, and elevating legrests as "must haves," or critical components of a power wheelchair (Ward et al., 2010). Thirty-two percent of clients with ALS use tilt 3-5 times per day, and 23% use it 11-20 times per day. Recline is used 3-5 times per day by 28%, and 11-20 times per day by 31%. Elevating legrests are used 6-10 times per day by 19% and 11-20 times per day by an additional 19%.

While users perceive their seat functions to be integral to their functional needs and comfort, they do not always adhere to regimens aimed at improving outcomes such as pressure relief (Schofield, Porter-Armstrong, & Stinson, 2013). The reasons why individuals may or may not use seat functions at the frequency or degree of angle recommended have recently been elucidated. A recent study (Titus, 2013) revealed that clients view seat functions as embedded and intermixed with their everyday routines and sometimes have difficulty separating out distinct functions (e.g. pressure relief) that need to be carried out independently. Furthermore some individuals may have problems with or dislike using a headrest when reclined or tilted back too far and also state that more extreme angles of tilt may interfere with some functional tasks or participation in some social activities. Therefore, clinicians must emphasize the importance and reasons for the use of the seat functions and conduct thorough training on appropriate usage and safety precautions (Liu, Cooper, Kelleher, & Cooper, 2013).

The below sections summarize the evidence from our prior Position Paper for use of tilt, recline, and elevating legrests to address various functional needs. Justification for these features based on additional or more recent scientific evidence has been updated.

Postural Realignment and Function

The previous Position Paper demonstrated that seat functions are useful for gravity assisted positioning which can improve balance, access to the environment, postural alignment, and function, either while stationary or driving over various terrains. Additional research supports seat function use in assisting with many daily tasks and self-management. New clinical guidelines recommend incorporating seat functions into daily activities of people with various disabilities including muscular dystrophy and children with spinal cord injury and cerebral palsy (Bushby et al., 2010; Calhoun, Schottler, & Vogel, 2013; Mcnamara & Casey, 2007).

Physiologic and Orthopedic Implications, Transfers, and Spasticity

The prior Position Paper summarizes evidence for how the use of seat functions to improve postural alignment can help individuals manage orthostatic hypotension; improve visual orientation, speech, alertness, arousal, respiration, and eating; and carry out bowel and bladder programs. It also presented evidence that seat functions can improve biomechanical positioning which can reduce the risk of injury to the shoulders and to caregivers. It showed how individuals can use seat functions to change joint angles which in turn can help clients to independently manage tone. This can result in reduction in pathological movements. Finally, the role of seat functions in managing contractures and orthopedic deformities was also described in that manuscript. Provision of passive range of motion and accommodation of contracture angles are useful features of elevating legrests. Newer literature is lacking in all of these above areas, revealing important areas of future research.

Edema

The prior Position Paper describes how elevating legrests, when used in combination with tilt to elevate the legs above the heart by about 30cm, can be effective in managing edema. Newer research shows that in a control group of individuals without disabilities, using elevating legrests and tilting more than 30° in combination with full recline significantly improves lower limb hemodynamic states as measured by near-infrared spectroscopy (Fujita et al., 2010). However additional research using individuals with disabilities is needed.

Pressure Relief and Tissue Perfusion

The prior Position Paper provides extensive evidence for combining pressure relief cushions and a means for position changes as a way to prevent and treat pressure ulcers. While wheelchair pushups are often recommended as one way to relieve pressure, the prior Position Paper showed evidence that wheelchair users would need to perform pushups at a duration of 2 minutes, regardless of frequency, in order to reduce oxygen tension in tissue to levels when tissue was unloaded. Moreover, performing wheelchair pushups at recommended frequencies, which can be as high as one pushup per minute, predisposes individuals to repetitive strain injuries. A prior study (Makhsous et al., 2007) provides further evidence that standard wheelchair pushups may not be sufficient to recover tissue perfusion. Investigators used a manual wheelchair with a seat back in 5° recline and a seat cushion whose posterior portion tilted down and away from the user's sitting surface. Two 1-hour sitting protocols were compared: standard wheelchair pushups every 20 minutes versus alternating the seat angle from parallel to having only the posterior portion of the seat tilted down 20° every 10 minutes while the anterior portion remained parallel to the floor. The dynamic system provided effective reduction in interface pressure at the ischia that was adequate for complete recovery of tissue perfusion while wheelchair pushups were not effective.

The prior Position Paper also described the extent to which tilt and recline angles each relate to pressure values and evidence that the best pressure relief is achieved with a combination of these two functions. The combined evidence in the Paper suggested that when used alone, posterior tilt had been found to be ineffective at reducing pressure at angles less than 15°, and seemed to be associated with reduced shear at angles of 25° and reduced pressure at 65°. Recline has been thought to reduce seating pressure since it distributes pressure over a larger surface area, but when used without tilt was thought to increase the risk of shear. Recline of 120° combined with elevating legrests also significantly reduced pressure, but the greatest reductions in pressure were seen when combinations of tilt and recline were used together, with studies using 25-45° of tilt with 110-150° of recline.

Additional research using Laser Doppler flowmetry corroborates these findings. One study in individuals with spinal cord injury showed that tilt should be at least 35° to increase skin perfusion over the ischial tuberosities when combined with recline at 100° and should be at least 25° when combined with recline at 120°. It appears that a combination of less than 25° of tilt and less than 100° of recline may not be sufficient for effective pressure reduction for enhancing skin perfusion over the ischial tuberosities (Yih-Kuen Jan, Jones, Rabadi, Foreman, & Thiessen, 2010). A second study by the same investigators found that, compared to an upright sitting position, the combination of tilt of 35° and recline of 100° and the combination of tilt more than 15° with recline 120° significantly increases skin blood perfusion underneath the ischial tuberosities in spinal cord injury (Y-K Jan, Brienza, Boninger, & Brenes, 2011). Their third study in spinal cord injury showed that, compared with upright sitting, muscle perfusion at the ischial tuberosities is higher at tilt angles of at least 25° with recline of 120° and skin perfusion at the ischial tuberosities is higher at either tilt angles of at least 15° with recline of 120° or at least 35° with recline of 100° (Yih-Kuen Jan, Crane, Liao, Woods, & Ennis, 2013). Their fourth study, also in spinal cord injury, showed that tilt of 35° and recline of 120° did not change skin perfusion over the sacrum area, perhaps because more weight may have transferred to the thoracic and lumbar areas, rather than to the sacrum (Yih-Kuen Jan & Crane, 2013).

A second group of investigators found that in spinal cord injury tilting less than 20° was not effective for reduction in peak pressure index. Tilting more than 30° with recline at 100° significantly reduced the peak pressure index at the ischial tuberosities by 20% and at the sacrum by 10% compared to 0° of tilt. At tilt of 40° with recline at 100°, the peak pressure index at the ischial tuberosities and sacrum decreased by 40% (Giesbrecht, Ethans, & Staley, 2011). Finally, another study in participants with spinal cord injury showed no effect of tilt of 15° on pressure, but both mean and peak pressure were lower at tilt of 30°and more. Blood flow increased whenever individuals tilted to any angle from an upright position, but did not seem to change when tilting from 15° to 30° (S. E. Sonenblum & Sprigle, 2010; S. E. Sonenblum & S. H. Sprigle, 2011).

It appears that greater degrees of tilt and recline are generally associated with improved pressure profiles. Research using force sensory arrays to assess changes in mean buttock pressure in children without disabilities using 0, 15, 25, and 35° tilt and found that as tilt angle increased, pressure decreased (Chen, Wang, Liu, & Li, 2010). A second study (Sprigle, Maurer, & Sorenblum, 2010) investigated pressure changes during increasing degrees of power tilt, recline, and standing in those with spinal cord injury. The study confirmed that normalized forces linearly decreased at the buttocks as the angle of tilt or recline increased. A third study evaluated the effects of recline angles of 90-130° and found that in individuals with spinal cord injury peak pressure at the ischial tuberosities decreased as recline increased, but peak pressure at the sacrum did not change (Park & Jang, 2011).

An interesting new finding sheds light on dosage of tilt. Performing tilt of 35° with recline of 120° for a duration of 3 minutes is more effective than a duration of 1 minute in enhancing skin perfusion (Yih-Kuen Jan, Liao, Jones, Rice, & Tisdell, 2012).

Although the prior studies showed only a small effect on the sacrum, one additional study used a computer controlled system to apply alternating pressure to the sacrum of individuals with spinal cord injury at either 60 or 0 mm Hg every 5 min to simulate effects of alternating pressure relief surfaces (Y-K Jan et al., 2011). Alternating pressure, as compared to constant pressure, increased sacral skin perfusion significantly. Another study (Shabshin, Ougortsin, Zoizner, & Gefen, 2010) in able bodied individuals showed that tilting laterally at 10° increased pressure significantly on one side of the sacrum while decreasing the pressure on the other side. These studies show that pressure relief can theoretically be obtained through lateral offloading but the benefits of temporary relief on one side must be weighed with the risk of increasing pressure on the other.

In summary, although pressure has been defined in various ways in different studies, and participant groups have differed, the results of the prior position paper, combined with additional new evidence, seem to suggest the following:

- Tilt and recline affect pressure and perfusion at the skin and muscle tissue at the ischial tuberosities, and to a minimum extent, at the sacrum.

- Tilt, when used alone, must be greater than about 25° to achieve pressure relief and/or tissue perfusion at the ischial tuberosities.
- Recline, when used alone, can increase shear but may provide reduction in pressure at the ischial tuberosities at angles greater than 90-100°.
- The greatest reductions in pressure are seen when tilt and recline are used together, either at tilt of 35° with recline 100° or tilt of 15-25° with recline of 120°.
- Greater angles of tilt and recline generally provide better pressure relief.
- 3 minutes duration of 35° tilt with recline of 120° is more effective than 1 minute.
- Lateral weight shifting may sufficiently offload the ischial tuberosities on one side, but also simultaneously increase pressure on the other.

Pain, Fatigue, and Sitting Tolerance

The prior Position Paper showed that wheelchair users utilize seat functions most often for comfort, and that pain may be related to prolonged sitting, pressure, and inability to change position. According to a recent publication, the majority of power wheelchair users relate their pain to their underlying medical conditions and also in some cases to improperly configured wheelchairs (Frank, De Souza, Frank, & Neophytou, 2012). About 25%, however, feel that their wheelchair can be used to treat their pain by allowing position changes (Frank et al., 2012). Several additional studies found that the majority of wheelchair users utilize seat functions most for comfort. Angles of tilt from 5°-15 and recline from 95°-110° are frequently utilized to increase sitting stability and assist with functional activities (Dewey, Rice-Oxley, & Dean, 2004; Ding et al., 2008; Lacoste, Weiss-Lambrou, Allard, & Dansereau, 2003; S. Sonenblum, Sprigle, & Maurer, 2009; S. E. Sonenblum & S. Sprigle, 2011). Also, wheelchair users report less discomfort when experiencing vibration when they are in a reclined position than in a upright sitting position (Paddan, Holmes, et al., 2012; Paddan, Mansfield, et al., 2012).

Dynamic Movement

The prior Position Paper reviewed the clinical consensus on how the use of seat functions allows an individual to assume a variety of postures throughout the day that are natural for the body. These postures are necessary for an individual to remain productive and functional. One study evaluated students without disabilities using adjustable furniture. Encouraging periodic movement improved posture and productivity, and it decreased pain (Cardon, De Clercq, De Bourdeaudhuij, & Breithecker, 2004).

Summary

It is RESNA's position that tilt, recline, and elevating legrests are medically beneficial for wheelchair users by: improving functional reach and access to enable participation in ADLs; managing posture and fatigue; improving mobility and lower limb function in those with some preservation of lower limb strength; improving range of motion and reducing the risk of contractures; promoting vital organ capacity including pulmonary, bowel and bladder function; promoting bone health; improving circulation; reducing abnormal muscle tone and spasticity; reducing the occurrence of pressure ulcers and skeletal deformities; and providing numerous psychosocial and quality of life benefits. The findings in this paper are supported by select peer-reviewed literature and current clinical practice.

C. Limitations of the current literature

The literature lacks randomized, controlled trials and other high level scientific studies evaluating outcomes from the use of these technologies. Another limitation is that some studies used ergonomic chairs or individuals without disabilities.

D. Case Examples

Client 1 is a 60 year old female with a degenerative muscle disease. She lives with her husband and is dependent for transfers using a mechanical lift. She had been using a power wheelchair without power seating functions for more than 5 years. She is very active in participating in activities in the family, the church, and the community. They go out frequently using a wheelchair accessible van. She constantly has pain over her buttocks, hips, and legs, and has to ask her husband to reposition her or change the locations of removable padding several times a day. Her legs and feet are usually swollen and cold with cyanosis, sometimes preventing her from wearing shoes. She recently received her new power wheelchair with power tilt, recline, and elevating legrest functions. She received education and training about power seat function usage and has been elevating the legs above the heart. She has noted that her pain level has significantly decreased, and the temperature and color of her legs and feet also improved significantly. She also can now wear shoes. During transportation using the van, she sits with a small degree of tilt, in which she feels more stable and comfortable than sitting upright. She does not need to ask her husband to reposition her, and she and her husband expressed that she is overall happier with this new system.

Client 2 is a 61 year old year old male with Multiple Sclerosis and spasticity. He currently uses a 7+ year old power wheelchair equipped with power seat functions. He is no longer able to conduct independent transfers and weight shift activities due to weakness in all his extremities. Power tilt has allowed him to independently weight shift and through gravity assist positioning it has improved his comfort to spend at least 12-14 hours per day in this wheelchair. Power recline has allowed him to open up the hip angle to allow for dressing of lower extremities while remaining seated in the chair. The recline feature has been used in combination with elevating legrests to reduce dependent edema. Elevating legrests have also allowed him to continue to independently change the position of the legrest support, while remain safely seated in the wheelchair and to effectively manage his range of motion.

Client 3 is a 28 year old male with a diagnosis of paraplegia from a spinal cord injury since 2006, as well as a history of multiple pressure ulcers. Until 2011 he lived in a nursing home, using a manual wheelchair full time. After being discharged into the community to his own apartment, he was evaluated for an optimally configured wheelchair and seating system to encourage wound healing and support his posture. The physical assessment found a stage IV right trochanter ulcer, a right ischial tuberosity stage III ulcer and a left ischial tuberosity stage II ulcer. Also, due to the development of heterotopic ossification, he was significantly limited in hip range of motion, lacking 40 degrees in the right hip and 50 in the left from a functional seated position. An order was generated through his insurance for a power wheelchair with power tilt, recline, elevating legrests and seat elevator. Within two months of receiving this wheelchair, both ischial tuberosity ulcers showed healing. By the fourth month they had both healed. In the fall of 2013 his power wheelchair was in disrepair and he was forced to sit in his custom manual wheelchair again temporarily. Within two weeks, the right ischial tuberosity ulcer recurred to a stage II. When his power wheelchair was repaired and he began to use it again, this wound healed within three weeks. Because the power wheelchair allowed him to position in the allowable range for his hip while allowing him to sit upright for independent function and tilt and recline back for weight shifting, he has achieved wound healing and remains functional and independent in his home and community.

E. Issues Related to Practice, Policy, and Research

A dearth of literature exists on long term outcomes related to provision of seat functions and comparisons of different clinical models of their provision. More research is also needed on the impact of policy and funding on user outcomes.

V. Triggers of New Findings that Would Require an Update of the Position

A new published formal, scientific meta-analysis, would provide stronger evidence than this Position and would require an update of the current Position. However, at this time insufficient literature exists to conduct a formal, scientific meta-analysis.

VI. Relation of this Position Paper to the other Position Papers

This Position Paper is an update of the previously published Position Paper (Dicianno et al., 2009).

VII. Summary of the Position Paper Development

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 AT standards; promoting research and public policy; and sponsoring forums for the exchange of information and ideas to meet the needs of our multidisciplinary constituency. Find out more at www.resna.org.

This Position Paper was developed through RESNA's Special Interest Group in Seating and Wheeled Mobility (SIG-09). The authors of this manuscript are clinicians and researchers experienced in the field of AT, and specifically, the seat functions discussed in this manuscript. A working group was established from RESNA members interested in this topic who volunteered to serve on the Position Paper revision committee. Each member conducted a literature review of articles which were published since the previous Position Paper and indexed in Pubmed. The search included papers that evaluated individuals with disabilities and also control participants wherein the content was relevant to the effects of seating and positioning on body structures and function. The team compiled references into a complete bibliography which was then reviewed and summarized. Additional articles were found through reviewing the bibliographies of individual manuscripts. This search identified articles which were not part of the original Position Paper. A draft manuscript was posted on the RESNA website, and the authors read and incorporated the comments that were posted. The process for position paper development, review, and approval is discussed further in the Procedures for the Development and Approval of RESNA Position Papers on Clinical Practice available at www.resna.org.

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