RESNA Position on the Application of Dynamic Seating

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A. About This Paper

This is an official RESNA Position Paper on Clinical and Professional Practice. As such, it has been prepared in accordance with the specific guidelines and approval process defined by the RESNA Board of Directors for Position Papers. See http://www.resna.org/knowledge-center/position-papers-white-papers-and-provisionguides for a complete description of this procedure. Key aspects of this procedure include: 1. Establishment of a Working Group of three or more experts to author the paper, using evidence from the published literature, documented best practices, and other input from experts in the field as the basis for the content. 2. Review of the draft by at least two subject matter experts from the relevant RESNA SIG or PSG, as well as all interested SIG or PSG members, and subsequent revisions. 3. Circulation of the revised draft to RESNA members and others for a 60-day public comment period, and subsequent revisions. 4. Review of the revised draft by the RESNA Board of Directors, and subsequent revisions. 5. Final approval of the paper by the RESNA Board of Directors.

B. Introduction

The purpose of this document is to share typical clinical applications as well as provide evidence from the literature supporting the application of dynamic seating 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 opinion 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.

For the purposes of this position paper, “dynamic seating” is defined as movement which occurs within the seating system and/or wheelchair frame in response to intentional or unintentional force generated by the client. Dynamic components absorb force. When client force ceases, the stored energy is returned through the dynamic component, which in turn assists the client back to a starting position (see Figure 1).

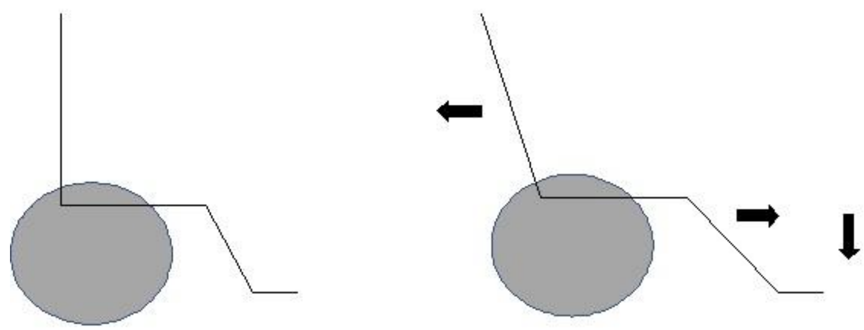

Figure 1: Dynamic seating moves in response to client forces.

Most wheelchair seating systems are static and if the client can move, this movement occurs independent of the seating system. Allowing movement within a dynamic seating system and/or wheelchair frame enables the client to move while maintaining contact with support surfaces which provides stability and reduces shear forces (Hahn, 2009; Cimolin, et al, 2009; Chen, et al., 2018; Crane, et al., 2007; International Dynamic Seating Workgroup, 2019 [clinical consensus]). Dynamic seating should not be mistaken for adjustability.

Dynamic seating has many potential applications. Dynamic components absorb force, protecting the wheelchair user from injury caused by sustained and/or repeated forces and reducing damage to the seating system and wheelchair. Movement provides sensory input which many clients seek out. Dynamic seating components may improve postural control, stability, and function, as well as enhance movement.

Dynamic seating components may be integrated within a wheelchair frame and typically allow more than one type of movement. Other dynamic seating options are modular and can be placed on a variety of wheelchair frames to capture one or more specific areas/planes of movement. Dynamic seating may also be incorporated into separate seating systems such as back supports. Common modular options allow movement at the pelvis, knees, and head (Eason, 2011, 2015; Freney & Schwartz, 2015; Lange, 2013; Presperin-Pedersen & Eason, 2015).

C. Definitions

Dynamic, in the context of physics, is defined as "of or relating to physical force or power" and "marked by usually continuous and productive activity or change" (Merriamwebster.com, 2019). Force is a vector, embodied by magnitude and direction. A wheelchair user exerts force onto a dynamic component in a specific direction or directions at a certain magnitude. Work results from forces acting upon an object and can either cause or hinder motion. Within dynamic seating, the individual is imparting 'work' on the dynamic component, resulting in its displacement or movement. Power is the rate of performing work and is represented by work/time. A person provides more power when displacing the dynamic component rapidly rather than slowly. The dynamic motion imparts kinetic energy into the system. As the dynamic components displace, the kinetic energy is stored as potential energy, typically by displacing springs or polymers. This potential energy allows the dynamic component to return to its original position when the force is removed.

Watanabe (2016) described three distinct ways that the word ‘dynamic’ is used in wheelchairs and seating when pertaining to complex rehabilitation technology (Complex Rehab Technology (CRT) products include medically necessary, individually configured devices that require evaluation, configuration, fitting, adjustment or programming, (NCART, 2020)): dynamic seating refers to 1) seating systems, 2) wheelchair frames, and 3) components, which move with the individual. The individual’s movement translates force into motion of a portion of the seating system and/or wheelchair frame and, as a result, allows, rather than blocks, the motion of the client (Lange, 2016).

A recent review of the literature revealed several different ways in which the term “dynamic seating” is used. This term is sometimes used to describe wheelchair seat cushions which alternate pressure under the client, similar to an alternating pressure air mattress (Burns & Betz, 1999). In other instances, the term is used to describe changes in pressure between the client and a seat cushion that occur during self-propulsion of a manual wheelchair (Kernozek & Lewin, 1998). Still others use this term to describe the movement between a client and a static seating system, rather than the client being in constant contact with the support surfaces (Aissaoui, et al., 2001). Some wheelchair frames include suspension. Suspension can reduce vibration and jarring from uneven terrain. While important, suspension is different from dynamic seating, which is activated by client forces and then returns a client to a preferred starting position. This position paper defines dynamic seating as *movement which occurs within the seating system and/or wheelchair frame in response to intentional or unintentional force generated by the client. Dynamic components are designed to absorb force and return energy to assist the client back to a starting position.*

As mentioned in the introduction, dynamic seating components may be integrated within a wheelchair frame and typically allow more than one type of movement, such as hip and knee extension. Other dynamic seating options are modular and can be placed on a variety of wheelchair frames to capture one or more specific areas/planes of movement. Common modular options allow movement at the pelvis, knees, ankles, and head. Other dynamic components include secondary supports, such as anterior trunk supports, which are made of material that stretches in response to an individual's movement and then assists the individual back to a preferred starting position. For example, an individual can lean forward to extend their functional reach and be assisted back to an upright position.

D. Rationale for the Position

Dynamic seating can be used in numerous clinical applications. Some of these are directly supported by research and other applications are reported by practitioners in the field. Each clinical application is discussed in more detail in the sections that follow.

1. To protect the wheelchair user from injury
2. To protect wheelchair and seating hardware from breakage
3. To increase sitting tolerance and compliance
4. To enhance vestibular input
5. To facilitate active range of motion
6. To increase alertness
7. To decrease agitation
8. To decrease fatigue
9. To increase function

10. To increase strength and postural control

11. To reduce active extension

12. To reduce energy consumption

(Lange, 2013; Presperin-Pedersen & Eason, 2015).

Dynamic seating is used in three primary clinical scenarios. First, it is used to absorb and dissipate client force that could otherwise lead to client injury, equipment breakage, decreased sitting tolerance, increased agitation, decreased function, and further increases in extension and energy consumption. Secondly, it is used to allow movement to provide sensory input, increase alertness, and decrease agitation. Thirdly, dynamic seating can improve postural control, stability, and function (Furumasu, 2018), as well as provide active range of motion.

1. Force Absorption and Dissipation

Many clients using wheelchair seating have increased muscle tone. This can lead to active extension, particularly at the hips, knees, and neck. When a client extends against a static seating system, the forces exerted against the foot supports, seat, back support, and head support are not absorbed or dissipated, and this can lead to an actual increase in episodes of client extension. It is well known that spasticity increases with resistance, such as client forces exerted against a non-yielding surface (Bar-On, et al., 2018). These forces are common in clients with central nervous system diagnoses such as cerebral palsy, traumatic brain injury and Huntington's disease. Increased muscle tone or spasticity is caused by an imbalance of nerve signals between the central nervous system and the muscles (Bar-On, et al., 2015). In addition to increased muscle tone, primitive reflexes and involuntary movements may also be present (Bar-On, et al., 2015). Muscle tone is not a constant state. Many clients may appear to be quite relaxed while sitting in their wheelchair seating system. However, many factors can lead to sudden and forceful extension, particularly at the hips, knees, and neck. This extension is often maintained for a short period of time and then subsides. One study found that clients with increased extension were able to exert up to 200% of their body weight against the back support and up to 600% of their body weight against the foot supports during extension (Samaneein, et al., 2013).

Dynamic seating absorbs the energy that the user imparts on the seating system through his or her muscular forces, and this can lead to dissipation of extensor tone. Avellis et al. (2010) used quantitative movement analysis to compare movement during an extensor thrust with a dynamic back support and a rigid back support and noted decreased extensor thrust. Crane et al. (2007) examined the effectiveness of an experimental dynamic wheelchair seating system and found reduced spasticity intensity. Ferrari (2003) observed decreased intensity and duration of extension at the trunk and head, decreased hyperextension of the neck during spasms, and decreased extension of the lower limbs when a dynamic seating system was used.

Many clients with increased muscle tone also display dystonia. Dystonia is characterized by involuntary, patterned, sustained, or repetitive contractions of opposing muscles, resulting in abnormal twisting body movements and abnormal postures (Schmidt, et al., 2011). Movements are often asymmetrical and so dynamic seating must accommodate this. Dystonia can lead to pain (Penner, et al., 2013) and discomfort and impact function. In a recent paper, Gimeno and Adlam (2020, pg. 3) hypothesize that "the use of whole-body dynamic seating can improve comfort, activity, participation, and quality of life in young children with dystonic cerebral palsy." They propose a protocol for future research on the efficacy of dynamic seating for people with cerebral palsy, as little research has been published on this specific clinical application. Previous research (Cimolin, et al., 2009) found reduced large upper extremity movement and increased smoothness of movement in research participants who had the diagnoses of cerebral palsy and dystonia.

a. **Dynamic seating is often used to prevent/decrease client injury and equipment breakage.**

Extension forces can lead to pain and, as a result, decrease sitting tolerance (Cimolin, et al., 2009; Crane, et al., 2007; Incoronato, 2007). Movement has been shown to decrease pain in wheelchair users (Lyons, et al., 2017; Frank & DeSouza, 2017). Pain prevalence in wheelchair users is concerning. One study of children with cerebral palsy found that nearly 55% of participants reported pain (Penner, et al, 2013) and another study found that 75% of children with cerebral palsy were in pain (Novak, et al., 2012). Frank, et al. (2012) found that most power wheelchair users in their study experienced pain and that one strategy that reduced pain was changing position. Comfort is a high priority for families (Gimeno, et al., 2013). Dynamic seating provides movement and has been shown to decrease pain (Crane, et al., 2007; Incoronato, 2006). Crane et al. (2007) found increased comfort (decreased pain) in subjects trialing a dynamic wheelchair seating system. Incoronato (2006) found a reduction in pain with use of a specific dynamic seating system in a retrospective study.

The forces from this extension on the client's body can lead to injury (Hong, 2006). Extension causes tremendous force through joints and can even lead to joint damage and bone fractures. Repeated and strong impacts between the head and the head support could even lead to concussions. A concussion can occur when the head collides with force against a surface. Some clients using wheelchairs impact the head support with significant force, perhaps even enough force to cause brain injury. Degree of force and repetitive impacts only increase risk of injury. Dynamic components absorb force, reducing this risk. Clients who extend against a head support with sustained force are at risk of neck injury (including strains) due to forces occurring through the soft tissue and vertebrae of the neck.

Decreased upper extremity dystonic movement found by Avellis, et al. (2010) and Cimolin, et al. (2009), could reduce injury caused by large and uncontrolled upper extremity movements.

Shear forces (an applied force that tends to cause an opposite but parallel sliding motion of the planes of an object. Such motions cause tissues and blood vessels to move in such a way that blood flow may be interrupted, placing the patient at risk for pressure injuries (Miller-Keane, 2003)) can occur as the client extends against a static surface, which increases the risk of skin and tissue injury. Dynamic Seating can reduce shear forces, as the seating surfaces move with the client, maintaining improved contact (see Figure 2). Avellis et al. (2010) and Cimolin et al. (2009) used quantitative movement analysis to compare movement during extensor thrust in a dynamic back support and a rigid back support and found decreased vertical trunk movement during extension. Crane et al. (2007) found reduced contact pressures in their study. Ferrari (2003) noted that subjects maintained body alignment with the components of the posture system during and after spasms.

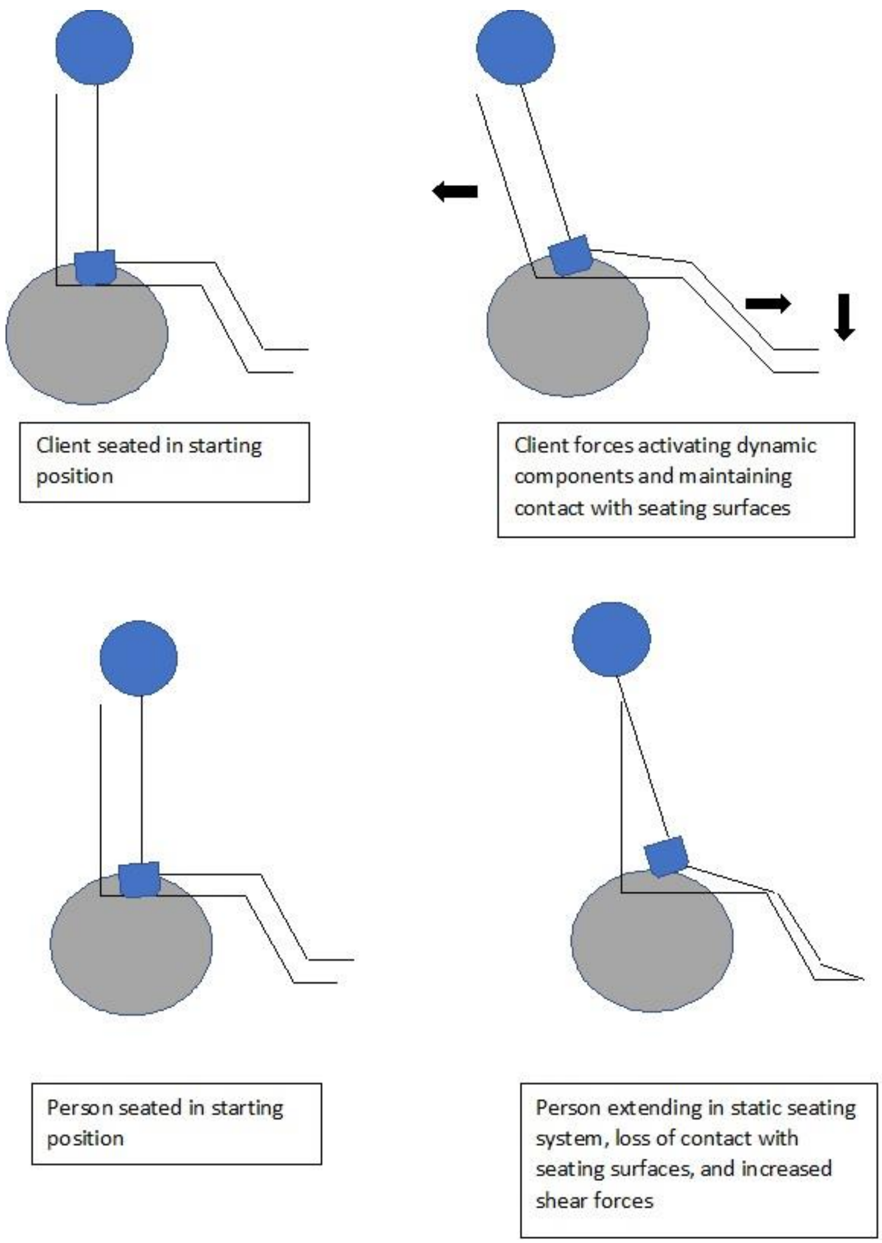

Figure 2

Many clients with intellectual disabilities tend to move a lot and frequently rock in their wheelchair seating system. This rocking movement may be so strong as to literally “bounce” a manual wheelchair across the room and can lead to the wheelchair tipping over and causing client injury. Dynamic seating moves in response to this rocking movement, which may reduce the risk of tipping the wheelchair over. In a 1997 study by Gaal, et al., wheelchair tips and falls were the most found wheelchair incidents, followed closely by component failures. While this study did not isolate wheelchair incidents in any single population of wheelchair users, it highlights this as one of the main potential causes of wheelchair rider injuries.

b. **Dynamic seating is often used to prevent equipment breakage**.

The forces from this extension on a static wheelchair seat and frame can be so strong as to cause damage to equipment (Hong, 2006). Hardware used to mount the seating system and components (such as a head support), are particularly susceptible to damage. Breakage frequently occurs at the foot supports, leg support hangers, back support mounting hardware and head support hardware (Hahn, 2009). These forces are not entirely dependent on the client's size. Even lightweight clients can exert enough repeated force to cause breakage. If breakage occurs, the client is also at risk of injury from contact with sharp surfaces.

Dynamic seating is designed to absorb these extreme forces, which in turn, protects the wheelchair seating and frame from wear and tear and even breakage (Crane, et al., 2007; Incoronato, 2007). Less breakage means clients can use their equipment with fewer repairs, less interruption to life, and less funding and documentation requirements.

Dynamic seating components at the neck absorb forces exerted by the client which may have led to equipment breakage in the past and can prevent future breakage. The dynamic component absorbs these forces, whether from extensor tone or forceful or repetitive collision with the head support, protecting the head support and hardware from damage. Breakage may result in the client being unable to use their wheelchair until repairs are made or the head support is replaced.

Continuous rocking, as well as forceful rocking, can lead to damage of the wheelchair seating system and frame (Crane, et al., 2007; Incoronato, 2007). Providing dynamic seating, particularly at the hips, allows the client to rock and move while absorbing these forces. This is typically addressed with a dynamic back support. Absorbing the force protects the wheelchair and seating system from damage.

2. Allowing Movement to provide Sensory Input

We all seek movement. The seated posture is not a static posture, and all sitting includes some degree of movement (O'Sullivan, 2012). Many clients move, not due to increased extensor tone, but rather for the intentional purpose of moving. The brain tends to seek out movement; people are wired to move because movement has so many benefits. Intentional movement helps us to understand our world and our relationship to the world (de Graaf-Peters, et al., 2007). Movement is the building block of perception and learning (Ferre & Harris, 2015). Movement can calm (reduce agitation), arouse (increase alertness), strengthen muscles, enhance visual control, and provide comfort (Crane, et al., 2007), as well as improve voluntary functional movements (Chen, 2018; Phillips, 2017) by varying our position. Research has shown that when intentional movement occurs, the brain is developing through neuroplasticity (Rossini & DalForno, 2004; Campbell, 2009). This occurs through experience dependent activity that increases the amount of brain derived neurotrophic hormone, which is critical in developing new axon and dendrite connections (Voss, et al., 2017; Wittenberg, 2009). Movement also supports an enriched environment that is needed for improved brain function (Morgan, Novak & Badawi, 2013).

From a sensory standpoint, movement provides vestibular input. The vestibular system is responsible for processing movement, changes in head position, and direction and speed of movement. The vestibular system lies in the inner ear. When the vestibular system is activated, the brain can be either calmed or aroused (Pfeiffer et al., 2008). An agitated client may become calm (decreased agitation) when the vestibular system is activated; a sub-aroused client may become more alert. Maladaptive behaviors may be reduced in response to movement (Pfeiffer, et al., 2011). Dynamic seating has been shown to increase attention. Rollo, et al. (2017) reviewed 5 studies and found that classroom based dynamic seating improved attention. One study showed that clients with dementia who were agitated, calmed in response to rocking. Other clients with dementia who were sub-aroused became more alert and responsive after rocking, specifically with reduced depression and anxiety (Watson, et al, 1998). Dynamic seating can increase sensory input (Presperin-Pedersen & Eason, 2015 [clinician consensus]).

Dynamic seating can also provide proprioceptive input. Active movement may occur to gain increased proprioceptive input (Prochazka,1986) for improved body and spatial awareness (Chu, 2017). This can, in turn, improve function (clinician consensus).

3. Improved Postural Control, Stability, and Functioning and Enhanced Movement

Dynamic seating also provides controlled resistance to movement initiated by the wheelchair user, usually through spring, elastomer, or hydraulic/pneumatic type mechanisms. Movement against resistance has been demonstrated to increase strength in people with increased muscle tone (McBurney, et al., 2003) without an increase in spasticity (Fowler, et al., 2001). Increased muscle strength can, in turn, improve postural control and functioning.

Numerous studies have demonstrated improved postural control and stability as a result of dynamic seating intervention. Adlam, et al. (2014) found increased head control and increased symmetry in posture using a dynamic seating system. Incoronato (2007) noted improved posture in their study and Crane, et al. (2007) noted improved postural stability. McNamara & Casey

(2007) found improved overall positioning, including reduced sacral sitting. Brown, et al. (2018) found an increase in head control after use of a specific dynamic seating component at the head.

Enhanced movement and improved functioning have also been found in people using dynamic seating. Adlam (2015) found increased function with use of a dynamic seat in one study and in another (2014) one subject was able to access a switch when using dynamic seating. Crane, et al. (2007) noted improved function. Incoronato (2006) found improvement of motor control of the upper extremities, trunk, and head. Dalton, (2014) found increased head and arm control with a simulated dynamic foot support. Cimolin, et al. (2009) noted increased smoothness of movement. Several other functional changes have been documented. Dynamic seating has been found to reduce energy consumption and fatigue (Ferrari, 2003) and increase range of motion and movement (Adlam, et al., 2014; Avellis, et al., 2010; Hahn, et al., 2009; Incoronato, 2007). Medically, dynamic seating improves digestion (Incoronato, 2007), breathing (Crane, et al., 2007; Ferrari, 2003), vocalization (Adlam, et al., 2014), and visual field. (Ferrari, 2003). Patrangenaru (2006) noted that static seating can lead to circulation-related issues. Finally, Adlam, et al. (2015) found increased social engagement with dynamic seating intervention.

A dynamic back may assist with self-propulsion as the length of stroke is increased. In one case study, the therapist indicated that the stored energy appears to facilitate a forward stroke (T. Kittelson-Aldred, personal communication, January 29, 2020). Some clients have also reportedly been able to drive a power wheelchair with improved control when using dynamic components. Dynamic movement incorporated above the pelvis can enhance spinal extension and increase functional reach.

E. Integrated and Modular Dynamic Seating

Some dynamic systems, as designed by the wheelchair manufacturer, are integrated into the mobility base, meaning that the entire system must be purchased as a unit and cannot be retrofitted to other mobility bases. These integrated systems often provide movement at more than one joint/location of the body, such as the ankles, knees, hips, and cervical spine/head.

Other dynamic systems are modular, which are not included in the wheelchair as designed by the manufacturer, are typically added to the wheelchair as an aftermarket item and may be used on many different mobility bases. These modular components are typically designed and intended for one specific area of movement. Movement can be provided at one joint/location, such as the hips, or several modular components can be combined to provide movement in more than one area/segment of the body such as the ankle and knee.

F. Comprehensive Review of the Benefits and Application of these Technologies, Practices and Services

Previous sections have addressed the clinical applications of dynamic seating with supporting literature. The following sections provide further clinical indicators and contra-indicators for use of dynamic seating at specific body locations including the pelvis and trunk; knees, ankles, and feet; and head.

1. Allowing Movement at the Pelvis and Trunk

When a client extends or rocks at the hips, movement can occur at one or more specific locations. Extension may occur at the thigh-pelvis junction and/or the lumbar-thoracic junction. A dynamic back allows this movement into extension and then assists the client back to an upright sitting position. The dynamic component may absorb and dissipate force caused by involuntary motions such as hip and pelvic extension caused by spasticity or self-stimulation, or the dynamic movement may enhance an individual's ability to perform an action. When the dynamic component is placed in the lumbar-thoracic area, it can be used to enable an individual to reach further back for reaching, stretching, or propulsion. A rotational dynamic component can be incorporated into the back to assist with crossing the midline and lateral movement. When a client uses a standard reclining back support (without shear reduction), it is common for the pelvis to collapse into a posterior tilt upon return to upright (Chang, et al., 2020). Dynamic back supports return the client to a neutral pelvic tilt by placing the pivot point in the correct location, typically as close to the natural pivot point, as possible. If extension occurs at the lumbar-thoracic junction, the pivot point needs to be even higher. A dynamic back support can reduce the need to reposition a client, as the client moves with support surfaces, reducing shear forces.

An appropriately angled anterior pelvic support is also important to ensure that the pelvis returns to neutral following extension. Some dynamic components only allow incremental movement to protect seating hardware from breakage. These components are less likely to lead to a loss of client position as so little movement occurs.

If the client experiences a loss of trunk position upon return to upright, it is important to ensure that adequate posterior, lateral, and anterior trunk support is used to compensate. The client should experience decreased shear forces as the back now moves in response to client force, rather than the client extending within a static system. Just as the optimal pivot point facilitates the pelvis returning to neutral after extending, the optimal pivot point also reduces shear in the back (Dawley & Julian, 2003).

2. Allowing Movement at the Knees, Ankles, and Feet

Other common areas of movement are at the knees, ankles, and feet. Dynamic components in these locations may allow knee extension, a telescoping or lengthening movement, and/or plantar/dorsi flexion. In combination, the dynamic components can capture the arc of movement that occurs at the knee. Movement into rotation is generally not advisable, as rotation can cause knee injury. Evaluation of the lower extremity when moving will provide guidelines as to where the dynamic movement should occur. Some clients with tight hamstrings have limited, or no, active knee extension beyond where the lower extremities are positioned in the wheelchair. These clients may still benefit from a telescoping motion which can absorb and dissipate clients' leg extension forces without moving into knee extension. The feet will need to be in contact with the foot support to activate the dynamic component, and some type of foot and/or ankle strapping may be beneficial to maintain foot position on the foot support. Dynamic foot supports may be provided individually or together with a one-piece foot support. If forces are not symmetrical on each side of the body, individual dynamic foot supports may capture this movement more accurately.

3. Allowing Movement at the Head

Finally, dynamic movement may be provided behind the head as a part of the head support hardware. These dynamic components allow movement into neck extension and/or rotation. Extending the neck posteriorly beyond a neutral alignment with the trunk can trigger startle, postural insecurity, or reflexive responses in some clients. Some dynamic components only allow a small amount of movement which will still absorb forces and protect hardware for clients who do not tolerate larger degrees of movement. Other dynamic components allow greater movement in one or more planes to capture posterior and rotational movements. Dynamic head support hardware might enhance the functional goal of neck extension for individuals with spinal cord injury, multiple sclerosis, muscular dystrophy, or other diagnoses. As always, when considering head supports, dynamic or otherwise, it is critical that we consider where the support is consistently being provided. Typically, a wide variety of head support pads can be used.

4. Combining Movement

Dynamic components are often combined to allow movement at more than one location. Absorbing and dissipating client force in one area may result in less force in all areas of the body. Careful evaluation is required to determine where the client requires movement and if more than one area of movement is required to meet the goals of absorbing and dissipating client forces, providing movement, and/or increasing function.

G. Product Features

1. Direction of Force

The dynamic force exerted by the client can be bi-directional in one plane or multi directional in more than one plane (i.e. often including trunk, ankle, or neck rotation) (see Figure 3). Many clients have asymmetrical forces, so that one side of the body exerts more force than the other. This may result in rotation. Rotation may also be a part of a pattern of movement or reflexive activity. Some dynamic components respond well to rotation, while others may only respond with single plane movement.

Figure 3: bi-directional (left image) and multidirectional (right image) movement

2. Dynamic Component Mechanisms

The dynamic component may use mechanical (i.e. elastomers, springs, and/or hydraulic/pneumatic) or non-mechanical (i.e. air cushion) methods to absorb forces. Dynamic seating components can typically be adjusted to provide the optimal level of resistance for an individual. The individualized resistance should be selected such that the client is able to move the component and still readily return to a preferred starting position. Some mechanical methods may require periodic replacement in order to respond correctly. If a mechanical elastomer or spring has weakened, the dynamic component may no longer function properly, and may be unable to assist in fully returning a client to a preferred starting position.

3. Dynamic Component Lock-out

Many dynamic components can be “locked-out” to temporarily halt dynamic movement. This is most often found in dynamic back and head supports. The lock-out feature is typically recommended during transportation. The lock-out feature is sometimes used to prevent excessive movement during activities such as feeding and when the mobility base is traversing uneven terrain.

4. Dynamic Component Compatibility

This Position Paper focuses on dynamic components which can be used on manual and power wheelchairs. Some stationary activity chairs also include dynamic components.

H. Limitations

While there is a variety of literature supporting the importance of dynamic positioning and movement, there are very few controlled studies of the specific dynamic seating interventions described in this position paper. Much of the evidence related to the efficacy of these particular wheelchair seating components is currently anecdotal or based on expert opinion and clinical observations of individual cases. Controlled studies typically include small numbers of subjects (Cimolin, 2009; Hahn, 2009), as the population of wheelchair users who specifically benefit from this technology is not generally large within any one geographical location. Additionally, the populations of wheelchair users who might benefit from these technologies are rather diverse (e.g. TBI, CP, Huntington's disease, dementia), which further limits the availability of homogeneous samples for use in research. Several case studies and other small-N studies have been presented at scientific conferences as well as published in several types of literature (Lange, 2019; Eason, 2015; Freney & Schwartz, 2015; Lange, 2009). Despite this lack of large-N randomized, controlled clinical trials, there is a significant body of clinical experience over a number of years. Future research suggestions include N=1 designs, observational research, and patient-centered outcomes. More collaborative research is warranted.

Clinical contraindications and precautions must also be taken into consideration. If resistance of the dynamic component is not sufficient, the client may not return to a preferred starting position. If the alignment of the dynamic back's pivot point does not capture the movement of the client, loss of posture may occur. Caution should be used in determining use of a dynamic back support or dynamic foot supports for a client with a dislocated hip, as forces may translate to the hip area. Keep in mind, however, that forces through the hip may actually be higher without dynamic seating. If the client has significant asymmetries in their posture, it is important to ensure that the plane of movement of the dynamic components match the movement of the client to reduce chance of injury. For some clients, movement into neck hyperextension may cause startle, postural insecurity, or trigger a reflexive response. If a dynamic head support is used in this situation, it is imperative to ensure the neck does not move into this hyperextended position. Some clients who seek out movement may display an increase in self-stimulation behaviors as a result of movement being available in the mobility base.

Dynamic components typically add weight to the mobility base and may limit the ability to fold the mobility frame. If the user is not transported within the mobility base (for example, the client may be transferred to a car seat), these factors may impact transportation of the mobility base.

I. Relation of this Position Paper to other Position Papers

This position paper is closely related to the RESNA "Position on the Application of Tilt, Recline and Elevating Legrests for Wheelchairs" which was updated and most recently published in 2015 (Dicianno, et al., 2015). Although the emphasis in that position paper is related to the benefits of the application of these technologies for pressure management, the ability of the wheelchair user to re-position him or herself in the wheelchair system is described as a 'dynamic' property and several benefits of this technology (as well as the literature to support these benefits), are noted in this previous position. One of the major differences between this previous paper and the “Application of Dynamic Seating” described in the current paper is the technology itself. This position paper clearly defines “dynamic” seating as seating that allows the user to apply force that results in movement, rather than technologies (such as tilt, recline and power elevating leg supports) that provide a dynamic environment by actively moving the person’s body through a specified movement pattern. There is some overlap in the foundational literature upon which both of these positions rely on – Frank and DeSouza (2012) investigated the pain experiences of powered wheelchair users, which focused on one potential benefit of both of these dynamic interventions; and McNamara and Casey (2007) investigated the impacts of a variety of seat inclinations on the function of children with cerebral palsy – a key population that may benefit from dynamic seating interventions.

J. Summary

As documented above, dynamic seating has many potential applications that can benefit clients using wheelchair and seating technologies. Benefits to both the client as well as the equipment, have been widely documented in clinical practice and investigated in several research studies cited in this paper. Education is needed to increase awareness of the benefits of dynamic seating. Current integrated and modular dynamic seating products allow movement in different body regions. Product options continue to expand and improve to better match the needs of clients who benefit from movement. Finally, more research is required to validate clinical benefits and improve funding for these technologies.

K. Case Studies

1. Case Study #1: Eddie

Eddie is a 16-year-old young man with the diagnosis of cerebral palsy and epilepsy. He lives at home with his family. He has increased muscle tone throughout his body and frequently exhibits very forceful and large movements. He frequently displays a rocking movement within his wheelchair, as well. Eddie is non-ambulatory and uses a tilt-in-space manual wheelchair. He is non-verbal.

Eddie began using an adaptive stroller at a young age and later used a tilt-in-space manual wheelchair. He eventually moved to a different tilt-in-space manual wheelchair, as this was more durable and less likely to tip as a result of Eddie's strong movements. He is currently using a customized back support on this mobility base to accommodate spinal asymmetries and provide increased support. Eddie began using a dynamic back support three years ago.

Before using the dynamic back support, Eddie frequently injured himself in his manual wheelchair and seating system. He would lean forward and throw himself back, hitting the lateral trunk supports, which led to bruising on his posterior trunk. He would sometimes lean to the side before throwing himself back and actually get stuck on the lateral side of these trunk supports, causing injury to his lateral thoracic area from the hardware. Now that Eddie has a dynamic back support, he no longer leans forward and to the side and throws himself back. Instead, he rocks with the back support movement and no longer injures himself.

Eddie would previously extend in his static seating system, leading to friction on his back and a subsequent rash / friction burn due to these shear forces. Since using the dynamic back support, his skin has returned to normal.

In the past, Eddie had caused repeated damage to the wheelchair seating system and frame. He had broken the lateral trunk supports, the back support, and the foot supports. This damage was frequent, and Eddie sometimes could not use the wheelchair until it was repaired.

This led to time in bed and time away from school. Since receiving the dynamic back support, Eddie has not broken anything on the wheelchair frame or seating system.

Eddie has very high muscle tone and would extend with such force that he was ‘standing’ in the wheelchair seating system at times. Now that he is using the dynamic back support, this extension force is absorbed and dissipated. Eddie now maintains his posture in the seating system and his caregivers have noticed less force to his movements.

Eddie’s caregivers have also noted that he no longer loses his position due to extending and moving within a static seating system. Since using a dynamic back support, he is able to move while maintaining an appropriate position within the wheelchair seating system. Maintaining position provides an optimal posture for function and distributes pressure.

2. Case Study #2: Phillip

Phillip is an adult with intellectual disabilities. He lives at a residential center. He has increased muscle tone throughout his body. Phillip is non-ambulatory and non-verbal. He seeks out movement and tends to rock with his entire body in his manual wheelchair for much of the day.

Phillip was positioned in a tilt in space manual wheelchair with a linear back support and a seat cushion. He also had a wide, flat head support; lateral trunk supports; pelvic positioning belt; and lateral thigh supports. Although he was fairly well positioned, his constant rocking had led to increased wear and tear on his wheelchair frame and seating system. Phillip’s caregivers used the wheel locks to prevent the wheelchair from moving across the room in response to his rocking. He exerted so much force behind his movements that the solid tire had actually broken around the wheel lock numerous times.

The team had attempted to address his constant rocking in this wheelchair with a dynamic back support, however this product had failed due to Phillip's constant movements. The entire assembly was at risk of breaking and needed to be replaced. The wheelchair also included dynamic foot support components that were designed to rotate laterally in response to significant force. Phillip did not appear to be activating this dynamic component, as his movement pattern was primarily into knee extension. Phillip did not have any dynamic component at the head, and he impacted the head support with significant force throughout his day.

Phillip sought out movement, craving this vestibular input. He required movement at his pelvis, knees, and neck. He had movement at his pelvis, but the current dynamic back support was not durable enough. He had a dynamic component on the leg support hanger, but he was not activating it as this did not match his movement pattern. He also required durable components that he would not break.

A different dynamic back support, dynamic foot supports, and dynamic head support hardware were recommended for Phillip. Since receiving this equipment, his therapists report that he can move much more readily and greatly enjoys these components. Since receiving the new dynamic seating, he has not broken anything on his wheelchair or seating system. The dynamic back support is locked during transport for safety.

3. Case Study #3: Julia

Julia is a 30 year old woman with a T1 complete spinal cord injury resulting in paralysis from the waist down. Her rigid off-the-shelf back support provided support but prevented her from spinal extension at the lumbar level. Julia was provided with a dynamic back support which was customized to provide her with lateral pelvic support and movement of the spine above the pelvis. The customized dynamic back support allowed Julia to move into back extension at the thoracic level. She was able to propel her manual wheelchair using greater spinal extension and scapular motion which allowed her to grab the wheel further back, increasing the length of her forward push and decreasing the resistance at her shoulder girdle. She was also able to reach higher, giving her increased function in reaching upper cabinets and high shelves in the refrigerator, while being supported with static surface area contact posterior and lateral to her lumbar/sacral spine. She was also able to participate in sports with her children by being able to reach back and throw a ball. The ability to independently stretch her back while seated in the chair decreased her reported back pain. The spinal movement provided by the dynamic back support resulted in significant functional changes and increased sitting tolerance by decreasing pain.

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Appendix of Additional Resources

Summary of the Position Paper Development

Detail of the Development and Review Process