Power seat elevation: an overview of the evidence

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Summary

Aim: To summarize the available evidence related to the impact that power seat elevation can have on the life of an individual who uses a power wheelchair for mobility.

Methods: The primary source was a systematic literature review. Compared to other power wheelchair functionalities, there are relatively few research publications on power seat elevation. Therefore, the evidence was further expanded with three additional sources: 1) pre-clinical evidence including goniometer measurements of the range of motion and quantification of the potential functional reach at different power seat elevation heights, 2) supporting literature such as guidelines and position papers, 3) case reports of users of power wheelchairs with seat elevation. Evidence was summarized and graded in the ICF framework (International Classification of Functioning, Disability and Health).

Results:

The main findings are:

- With power seat elevation the range of motion in the shoulders and neck needed to reach or to be at eye height is lower compared to without elevation, which may contribute to the prevention of repetitive strain injury and pain.
- Power seat elevation increases the possible functional reach and thereby can increase environmental access at a variety of levels. This facilitates the performance of independent activities of daily living, transfers, and communication.
- Although there is limited large-scale research, case reports show that elevation may benefit participation in society and has positive impacts on independence and quality of life.

Conclusions:

It was concluded that power seat elevation brings the environment within reach and thereby reduces the required range of motion and the associated strain on neck and shoulders, as well as increases the possibility to independently perform activities of daily living. As power seat elevation enables to make the gap in height between the wheelchair and transfer surface as low as possible, elevation can improve the ergonomics of transfers. Individuals report that in reality, the impact of elevation is even greater, including positive impact on communication, participation, and quality of life.

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Overview of the evidence

All evidence was described in the different categories of the ICF-model, of which the overview is provided in Figure a.

Overview in ICF frame

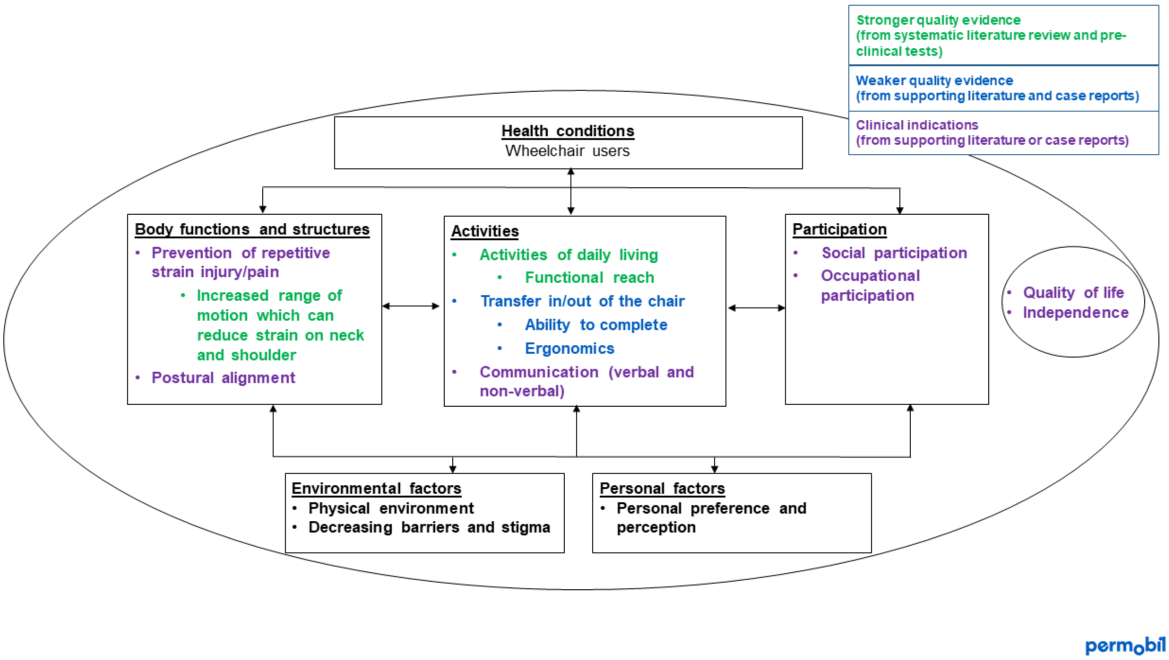

Figure a. ICF framework overview of the evidence for power seat elevation

Body Functions and Structures

Prevention of repetitive strain injury/pain

Research shows that with power seat elevation the range of motion in the shoulders and neck needed to reach or to be at eye height is lower compared to without elevation. This reduced strain may contribute to the prevention of repetitive strain injury and pain.

Background:

Wheelchair users are at a high risk of developing repetitive strain injury and experiencing pain (Liampas et al. 2021). Anytime that a person has to complete an activity over and over again under stress, they are susceptible to repetitive strain injuries, which can result in pain and joint dysfunction over time. For individuals using power wheelchairs, most of their environment requires reaching overhead and away from their body, which has been well established in contributing to pain and discomfort over time. Recurrent over-the-head shoulder movements have suggested to be one of the reasons for developing pain (Akbar et al. 2010).

Evidence:

Sabari et al. 2016 examined differences in active range of motion at the cervical spine and glenohumeral joint during performance of two functional tasks while seated in a wheelchair with the seat elevation feature at minimum and maximum height (8” or 20 cm). A total of 60 ambulatory individuals participated. When seated at the maximum elevated wheelchair seat height, goniometer measurements showed that they need a smaller range of motion at the shoulders to perform a reaching task compared to when positioned in the maximum studied elevation height (mean difference in shoulder abduction range of motion of 32° (SD=6)). Furthermore, elevation impacted upon active range of motion requirements for cervical extension during a computer viewing task, with the cervical range of motion being on average 9° less when maximally elevated (SD=5°). The authors conclude that wheelchair users may require more active range of motion at the shoulder and neck to perform daily functional activities while seated at the minimum wheelchair seat height, and thereby show the potential of power seat elevation in preventing repetitive strain injury and pain.

In the study of Sabari et al. 2016 the maximum power seat elevation height was 8” or 20 cm, however, several wheelchairs now have a higher elevation capability, which is hypothesized to make the restrictions in shoulder range of motion for reaching even less straining. Therefore, we have performed testing in a similar set up as the functional task goniometer measurement described by Sabari et al. 2016. Measurements were provided in one person (age = 31, standing height = 176 cm, torso length = 63 cm), at the same elevation height as well as on a higher elevation height of 29.8” (75.7 cm). See Figure 1 and Figure 2. All experiments were repeated 3 times by the same test participant and the mean of these 3 tests were presented. Results show that compared to seated at the minimum wheelchair seat height, shoulder abduction range of motion at the 8” (20 cm) was 35° lower. Furthermore, at 12” (30.5 cm) elevation, the shoulder range of motion was 55° lower. All results are displayed in Table 1 and more information about the methodology is provided in the methods section at the end of the full report.

Figure 1: Minimum seat to floor height of 17.5" or 44.45 cm (0 cm of seat elevation)

Figure 2: Maximum seat to floor height of 29.8" or 75.7 cm (30.5 cm of seat elevation)

Table 1. Shoulder abduction at minimum and at elevated height, combined results from Sabari et al. 2016 and our own lab tests.

	Lab tests, 3 repetitions n=1, Mean (SD) Distance to wall 35.56 cm
Shoulder abduction AROM, minimum seat height	134° (3)
Shoulder abduction AROM, 8" (20 cm) elevation	98° (2)
Difference in shoulder abduction AROM between 8" elevation and minimum	35° (3)
Shoulder abduction AROM, 12" (30.5 cm) elevation	79° (2)
Difference in shoulder abduction AROM between 12" elevation and minimum	55° (2)

Sabari et al. 2016 performed the measurements with a distance of 14" (35.56 cm) to the wall, and we used the same distance to determine the results described in Table 1. We were, however, also interested in showing the outcomes when the distance to the wall was slightly further away, allowing for the elbow to be in full extension.

Our test results show that the power wheelchair must be positioned 20” (50 cm) from the wall for our occupant to maintain a straight arm and touch the marker at 63.5” (161.29 cm) above the ground when the seat is in maximum elevation of 12” (30.5 cm). The results show that shoulder abduction range of motion at maximum seat height was 103° with a standard deviation of 2.65°, shown in Figure 3.

An additional investigation shows that the power wheelchair must be positioned 18” (46 cm) from the wall for the subject to maintain a straight arm and touch the same marker when the seat is in 8” (20 cm) of elevation. The results show that shoulder abduction range of motion at 8” (20 cm) of elevation was 113° with a standard deviation of 1.73°, shown in Figure 4.

Figure 3: Power wheelchair in 12” (30.5 cm) elevation positioned 50 cm from the wall.

Figure 4: Power wheelchair in 8” (20 cm) elevation positioned 46 cm from the wall.

Wu et al. 2017 studied the relation between power seat function usage and wheelchair discomfort amongst 13 power wheelchair users, of which 9 were new to power function use. Participants usage of seat function was measured with a device for 8 weeks, and they filled out a discomfort scale every day. Discomfort was measured with a scale which included a summary score of a general discomfort with sitting and intensity of discomfort score at seven areas of the body (back, neck, buttocks, legs, arms, feet, and hands). The frequency of using tilt, recline and legrest was correlated with discomfort intensity, but not elevation usage. A proposed explanation for the lack of a relation with elevation is that discomfort specifically for sitting was rated and a summary score of the whole body was considered, while the clinical benefit of power seat elevation is not a byproduct of static sitting but prevention of repetitive strain injury affecting only the shoulders and neck. Furthermore, most participants in this study have only used the power seat functions for a short period of time, while contrary to discomfort in the legs which may be possible to relieve more directly by elevating the legs, elevation of the seat and prevention of pain in the neck and shoulders is likely to be a longer-term effect.

In a case report, we can discuss the presentation of the ways that power seat elevation impact one individual's life. Scott is a 56-year-old male who was diagnosed with multiple sclerosis (MS) at 33 years of age. Initially when he first began having mobility limitations, he had a very standard power wheelchair without any power seat functions. As he began to have more fatigue, increased spasticity in his upper extremities along with progressive weakness, he required his technology to allow him to maintain his independence. Upon receiving a new power wheelchair with multiple seat functions, including power seat elevate, Scott reported that his reaching activities required less effort, energy and strain.

Postural alignment

It can be hypothesized that power seat elevation may allow users to remain in a more stable and upright posture while still maintaining their functional reach. As they no longer have to move to an unstable and unsupported position for functional reach, they are remaining in a safe and protective posture.

Postural asymmetries can be caused by multiple contributing factors including spasticity, paralysis, asymmetrical strength, visual deficits, functional activity requirements and in response to environmental barriers. Prolonged asymmetries can lead to skin breakdown, respiratory and digestion complications, scoliosis and joint contractures (Engstrom 1993). When a person has to move outside of their stable functional reach, they may not be able to bring themselves back up to an aligned position, which can result in poor postural alignment over time. When using seat elevate on a power wheelchair the person can bring their environment within reach and rely on the proximal stability from the wheelchair and positioning components to allow for distal mobility to complete a task (Lange & Minkel, 2018).

Activities

Activities of daily living

Power seat elevation increases the possible functional reach and thereby can increase environmental access at a variety of levels. This facilitates the performance of independent activities of daily living.

Background:

A wheelchair provides mobility for people with physical impairments, and thereby provides a way to perform activities of daily living. Besides mobility, activities of daily living require stable and comfortable positioning and the ability to reach. When using a power wheelchair for daily activities, being able to position the wheelchair in the environment can help to increase functional reach (Lange & Minkel, 2018). Performing daily care tasks such as dressing, meal preparation, personal hygiene require access to a wide variety of surface heights (Arva, et al., 2009)

Evidence:

As described in the section under body functions and structures with data provided in Table 1, for the same functional reaching task, the range of motion needed in the shoulders is lower. In our own lab experiments, we added another test to show how the functional reach increases from the minimum elevated position to the maximum elevated position. Reach was measured as the maximum height on the wall (measured from the floor) that could be reached by the test person, with range of motion of the shoulder standardized to 60°. Shoulder abduction beyond 60° has been discussed to be the risk factor for repetitive strain injury and pain (National Institute for Occupational Safety & Health, 1997). See Figure 5 for an image showing how the test was conducted. Results are provided in Table 2. This experiment was performed with the same test person as described previously and the mean of 3 repetitions was provided. Additional information about the methodology is provided in the methods section at the end of the full report.

Figure 5: Positioning to measure the maximum height on the wall that could be reached by the test person, with 60° range of motion of the shoulder.

Table 2. Possible reach height at 60° of shoulder abduction, at minimum and at elevated height, results from our own lab tests.

	Lab tests, 3 repetitions n=1, Mean (SD) Distance to wall 48 cm
Height (17.5" and 44.45 cm) at minimum elevation	28" (0.8) / 71 cm (2)
Height (25.5" and 64.45 cm) at 8" (20 cm) elevation	35" (0.8) / 90 cm (2)
Height (29.8" and 75.7cm) at 12" (30.5 cm) elevation	41" (0.4) / 103 cm (1)

An additional test was conducted to determine the maximum reach for the test person when the seat was in a fully elevated position of 29.8" (75.7 cm) from the ground surface. Figure 6 shows that for a shoulder abduction of 143°, at 9.45" (24 cm) from the wall, the test person can reach 78" (198 cm) from the ground surface when the seat is in full elevation.

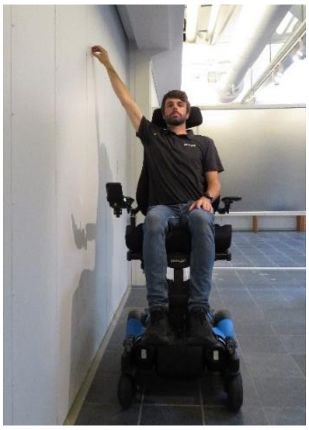

Figure 6: Power wheelchair positioned 9.45" (24 cm) from the wall with participant in maximum shoulder abduction while positioned in a 12" (30.5 cm) elevated seat.

Multiple research studies confirm that performing activities of daily living is a common reason to use power seat elevation. In a study of Sonenblum et al. 2019, how, why and where power seat elevation was used was studied amongst 24 power wheelchair users for 2-4 weeks. Consistent with other studies on use of wheelchairs, this study noted a large variability of use of the wheelchair and its power functions. The majority of the participants used power seat elevation for functional activities throughout the day. The in-seat activity level while elevated was found to be higher compared to while not being elevated. Furthermore, 23 out of 24 participants wheeled while elevated. Nine participants wheeled more than 20% of their bouts elevated. Another study performed by Ding et al. 2008 reported on use of self-actuated seating functions including tilt, recline and seat elevation, for a period of 2 weeks, amongst 9 power wheelchair users with seat elevation. Five out of nine subjects whose wheelchairs were equipped with seat-elevation functions reported using the seat elevator to reach things either at home, work, or in public; four reported using the seat elevator to reach higher levels. Examples of use included working at different levels, shop, turn on-off light switches, go to the bathroom, socialize, eat, read the calendar on the refrigerator, and reach elevator buttons. A third study, by Vance et al. 2021, had a qualitative design and evaluated power wheelchair provision amongst stakeholders with regards to ALS. Seat elevation was one of the most mentioned power wheelchair components. It was mentioned that "You may want a seat elevation to reach stuff on counters or in refrigerators.

Case reports give further insight into situations in which elevation is used for performing independent activities of daily living. Consider Karen, a 31-year-old woman with a spinal cord injury at the C6 level. Karen has no motor or sensory function below her level of injury, she has impaired hand function and poor trunk control. She has used a power wheelchair for over 15 years but has always required 8 hours of caregiver assistance as she is unable to reach dishes and cups from her cabinet and is unable to refill a water bottle to stay hydrated throughout the day. When she discussed how power seat elevation would impact her, she required less assistance to get dishes ready for meal preparation, allowing her to utilize caregiver assistance for critical tasks instead of shortening her time out of bed to just when she had a caregiver present. This gave Karen not only increased independence, but also an increased idea of self-sufficiency.

In addition, we can think about Caroline, a young woman living with Limb Girdle Muscular Dystrophy. She reports that power seat elevate allows her to have increased functional independence in her home. As a 27-year-old graphic designer and dog owner, she prefers to do as much as she can for herself without assistance from her mother. With power seat elevation, Caroline states that it provides "Independence in my house. You know the light switch and reaching for things. I wouldn't be able to function without that feature in a lot of areas of my life".

Transfer in/out wheelchair

Elevation enables to make the gap in height between the wheelchair and the transfer surface as low as possible, which may enable to complete a transfer, make transfers more ergonomic and may increase independence with transfers.

Background:

A transfer is when a person moves from one sitting surface to another. It is considered one of the most important daily and routine tasks for a person using a wheelchair (Barbareschi & Holloway, 2020). Transfers happen in a variety of ways depending on the individual and the environment (Lange & Minkel, 2018). A variety of transfer methods are helped or hindered based on the height of the surface as well as the height difference between surfaces. Strength impacts an individual's ability to overcome gaps in both the horizontal and vertical direction.

Evidence:

The presence of a gap in height has been identified as one of the most commonly reported difficulties when completing a transfer activity (Barbareschi & Holloway, 2020). In principle, what power seat elevation makes possible for transfers is making the gap in height between the wheelchair and the surface transfer as small as possible.

Different research studies confirm that performing transfers is a common reason to use power seat elevation. Sonenblum et al. 2019 provided device-measured data showing that 16 out of 24 wheelchair users (67%) transferred while elevated. Most transfers took place at heights less than 5 inches or greater than 9 inches, and 14 people changed seat height between the transfer out of the wheelchair and the return transfer at least one time. Transfers included lateral transfers, sit-to-stand transfers and dependent transfers. Of the 24 power wheelchair users, 15 answered to questions on the reasons for why elevation was used. Ten out of 15 (67%), reported that they used elevation for transfers. Participants using elevation for transfer purposes seem to use it for every transfer they make. Another study, by Ding et al. 2008 showed that 3 out of 9 persons in wheelchairs with power seat elevation reported that seat elevation facilitates transfers.

As reported in Arva et al. 2009, seat elevating devices can facilitate safer and more independent transfers. This can apply to people using a transfer board where going in a downhill direction uses gravity to assist and reduce resistance and difficult as well as decreased upper extremity strain. For people with lower extremity weakness, transferring into a standing position is more difficult from a low seat to floor height. When a surface is elevated, less strength is needed to transition into standing and less extensor activation of the hip, knee, and ankles are needed. (Arva et al., 2009). The case report of Anna-Claire gives further insights into how elevation is used to transfer. Anna-Claire is a 24-year-old woman with an incomplete spinal cord injury impacting both her upper and lower extremities. When she is seated in her power wheelchair at its lowest seat to floor height, she is unable to stand and pivot during a transfer and requires full assistance from a caregiver. When her seat is elevated approximately 8” (20 cm), she is able to place her feet flat on the ground, transfer her weight forward, and stand with minimal assistance from her caregiver.

Communication

Power seat elevation makes it possible to position oneself at the same line of sight with those not using a wheelchair. This can facilitate verbal and non-verbal communication and socializing.

Background: People seated in wheelchairs are positioned at a lower level than their standing counterparts, which forces an upward gaze to achieve direct eye contact.

Evidence:

The principle of power seat elevation, of having the possibility to change the height of the seat, makes it possible to position oneself at the same line of vision with those not using a wheelchair. There is a body of evidence showing the benefits of direct eye contact on both verbal and non-verbal communication with others and on the environment (RESNA 2019). In research projects, users have mentioned that they use elevation for communication and gaze (Sonenblum et al. 2019, Vance et al. 2021). A survey performed in 2021 by the ALS association with 352 responders also showed that seat elevation was used to engage with others at eye level, and in particularly also mentioned as the reason that seat elevation should be accessible for everyone.

Case reports further show how users report to use elevation or communication purposes. In the case of Scott, as previously mentioned, a 56-year-old man living with MS, he experiences fatigue that directly impacts his vocal cords and voice production. When he has to strain to verbally communicate it not only removes him from engaging in the conversation but also results in decreased about of time he spends interacting while seated in his power wheelchair. With the use of power seat elevation, Scott reports less vocal fatigue and speaking no longer feels like “lifting weights”.

For Tom, who utilizes a power wheelchair after a spinal cord injury and resultant paraplegia in 2000, the power seat elevate provides several benefits to his independence and personal freedom but also for his communication with others. Tom states, “I hold cooking classes for people with disabilities and then it is really great to use the seat elevate when I work. It is also very useful when I am working as a speaker because then everyone at the conference room can see me.”

Participation, Quality of Life, Independence

Although it has been only of limited focus in larger research projects, case reports show that elevation may benefit participation, independence and quality of life.

Background:

Quality of life and especially health-related quality of life is dependent on a wide range of factors and is malleable based on every individual’s lived experience. Provision of wheeled mobility has been found to improve quality of life (Davies et al. 2003).

Evidence:

Sonenblum et al. 2019 studied how, why and where power seat elevation was used amongst 24 power wheelchair users for 2-4 weeks. Participants' score on the Community Integration Questionnaire, which is a measure for home integration, social participation, and occupational participation was not related to the number of times they elevated daily. However, the community integration was only related to the frequency of elevation. It remains unknown whether providing elevation, comparing having elevation to not elevation, can impact social and occupational participation.

Life is participation, and when a person is not positioned in a way that they can interact with the world around them, their world becomes more about just what is happening within them and start to lose interest in their surroundings. We use our trunk, head and hands to communicate with the work, by providing opportunities for the person to see the environment and the people in it, we are increasing inclusion and acceptance (Engstrom, 1993).

It is frequently noted in case reports by users that seat elevation impacts their participation, quality of life and/or independence. For Scott, who is living with MS for over 20 years, being able to use seat elevation on his power wheelchair allows him to contribute to his community, facilitate communication and socialization, all of which have a positive influence on his life. Scott states that his power wheelchair “improves my functioning by allowing me to stay seated longer and gives the mobility I need to get out of bed, live independently, remain productive and mostly self-sufficient. I can engage in important societal volunteer work by serving on many boards and committees". In addition, something that many people take for granted, is that before he had power seat elevation, Scott's choices when he went to the grocery store were limited by what was within his reach. Many grocery stores, the less nutritious foods are located on the bottom shelves, which is all that Scott could reach. But once he received his power wheelchair with power seat elevation, his food choices were no longer dependent on what he could reach. This will have a long-term effect not only on his mobility and independence but also on his ability to make his own choices and take care of his health and wellness.

For Scott, power seat elevate meets his fluctuating needs to maintain his independence throughout his busy day. Not only for reaching and completing necessary activities but also to be able to communicate with people around him. This allows him to spend longer hours contributing not only to his household and daily needs but also to his advocacy and community work.

Personal and Environmental Factors

Physical environment

The world is designed for people who can stand and walk, and when sitting in a wheelchair on a lower level that makes a wide variety of environments inaccessible. Elevation is one of the power seat functions that can contribute to removing some of the barriers by making it possible to see and reach out at an environment that would not be possible from the regular seat height of a wheelchair (Sabari et al. 2016).

Decreasing barriers and stigma

The role that power seat elevation can play to decrease barriers and stigma can vary from person to person. It may depend on their past experiences as well as their self-perception. The way to understand the impact is through individual case reports, such as Caroline, who is a 27-year-old woman with Limb Girdle Muscular Dystrophy. She uses a power wheelchair full-time for her mobility and reports that with power seat elevation, her ability to be included and involved in her surroundings improves. When she is out with her friends in loud places or restaurants with high tables, she is able to be brought into the conversation both physically and emotionally. Marie, a 62-year-old woman with rheumatoid arthritis, has used a power wheelchair since 1984. When she recently obtained her power wheelchair with power seat elevator, she stated that it "…resulted in everyone listening to me in a different way than before. All of a sudden, I also existed, something which I have never thought about before".

When Tom utilizes his power seat elevation, he experiences increased personal freedom as well as increased independence. Tom has used a power wheelchair since 2000 secondary to a spinal cord injury. He reports that with a power seat elevation function on his wheelchair, he no longer has to ask others for help all of the time and provides him with "a sense of freedom and sense of being equal because I can manage by myself. It is all about my personal freedom and possibilities. With the height I don't get look down upon. In addition, people come up to me when I am in the elevated position and I get compliments due to that. "Oh where can you get that? Wow very nice!".

Personal preference and perception

That power seat elevation is a preferred feature amongst users is supported by the findings in a research study showing that even though elevation was not covered by insurance, 77% chose to purchase the addition of seat elevation (Ward et al. 2015). Insurance covered most advanced features on power wheelchairs; the only element that insurance covered less than 96 percent of the time was a powered seat that elevates. Insurance covered this feature for only about half of the respondents (ALS association 2021).

Sources

Systematic literature review

The primary source of this white paper is a systematic literature review, which was performed to identify the impact of power seat elevation on all outcomes of the ICF model. A search was performed using PubMed/Medline. The PICO (Population, Intervention, Control, Outcomes) framework was used to define the search and used the following key words. For Intervention, key words included: elevation, elevator, seat, seat height, or lift; for Population, the key words included wheelchair, disability, handicap or non-ambulatory. The search was not limited to any Comparison or Outcome. Search results were limited to identifying publications after 2010, but older relevant literature was snow-balled from included articles. The original search was performed in February 2021. This search identified 55 publications, which were systematically reviewed by title, abstract, and full text. A total of five studies providing quantitative or qualitative data were included in the main literature review. In February 2022 this search was repeated, identified four hits, and one study was added. All references used are listed in the reference list. All studies were graded by two reviewers on their quality, design and contribution.

Pre-clinical evidence

Tests were performed at the Permobil test lab in Timrå, Sweden in September 2022. Tests were performed in a Permobil M3 Corpus power wheelchair, with power seat elevation up to 12 inch (30.5 cm) and 20.5” (52 cm) seat depth. The test protocol was developed based on the study by Sabari et al. 2016, with a similar type of set up, as well as some extensions to it.

All tests were performed by one person, age 31, weight 69 kg, height 176 cm, torso length of 63 cm, and arm length 74 cm. The person is able-bodied with maximum active range of motion of approximately 140°.

Each test was performed three times, and in between each test the person stood up from of the wheelchair and sat down again. The mean value and standard deviation were calculated for each set of three tests and provided as the results. Standard deviation represents the variation within the person. Shoulder range of motion was measured with a goniometer.

The following tests were performed:

- Measurement of shoulder abduction, minimum seat height of 17.5” (44.45 cm) from the floor, at 14” (35.56 cm) distance from the wall (Figure 7)

- Measurement of shoulder abduction, elevation 8” (20 cm) (this was the maximum seat height in the study of Sabari et al. 2016), at 14” (35.56 cm) distance from the wall, and at 18” (46 cm) distance from the wall. (Figure 8 and Figure 9 respectively)
- Measurement of shoulder abduction, maximum elevation 12” (30.5 cm), at 9.5” (24 cm) distance from the wall, at 14” (35.56 cm) distance from the wall, and at 20” (50 cm) distance from the wall. (Figure 10, Figure 11 and Figure 12 respectively)
- Measurement of maximum possible reach height, for minimum seat height 17.5” (44.45 cm), at 19” (48 cm) distance from the wall. The tests were performed with a shoulder abduction of 60° (Shoulder abduction beyond 60° has been discussed to be the risk factor for repetitive strain injury and pain (National Institute for Occupational Safety & Health, 1997) (Figure 13)
- Measurement of maximum possible reach height, seat height 25.5” (64.45 cm), at 19” (48 cm) distance from the wall. Test were performed with a shoulder abduction of 60° (Figure 14).
- Measurement of maximum possible reach height, maximum seat height 29.8” (75.7 cm), 19” (48 cm) distance from the wall. The tests were performed with a shoulder abduction of 60° (Figure 15).
- An additional test was conducted to determine the maximum reach for the test person when the seat was in a fully elevated position of 29.8” (75.7 cm) from the ground surface.

Figure 7: Measurement of shoulder abduction, minimum seat height of 17.5” (44.45 cm) from the floor, at 14” (35.56 cm) distance from the wall.

Figure 8: Measurement of shoulder abduction, elevation 8" (20 cm) (this was the maximum seat height in the study of Sabari et al. 2016), at 14" (35.56 cm) distance from the wall.

Figure 9: Measurement of shoulder abduction, elevation 8" (20 cm), at 18" (46 cm) distance from the wall.

Figure 10: Measurement of shoulder abduction, maximum elevation 12" (30.5 cm), at 9.5" (24 cm) distance from the wall.

Figure 11: Measurement of shoulder abduction, maximum elevation 12" (30.5 cm), at 14" (35.56 cm) distance from the wall.

Figure 12: Measurement of shoulder abduction, maximum elevation 12" (30.5 cm), at 20" (50 cm) distance from the wall.

Figure 13: Measurement of maximum possible reach height for a minimum seat height 17.5" (44.45 cm), at 19" (48 cm) distance from the wall. The tests were performed with a shoulder abduction of 60°

Figure 14: Measurement of maximum possible reach height for a seat height 25.5" (64.45 cm), at 19" (48 cm) distance from the wall. Test were performed with a shoulder abduction of 60°

Figure 15: Measurement of maximum possible reach height for a maximum seat height 29.8" (75.7 cm), 19" (48 cm) distance from the wall. The tests were performed with a shoulder abduction of 60°

Supporting literature

In addition to the systematic review, supplemental publications have been utilized for areas such as background information and considerations, and clinical support has been added from practice guidelines and position papers. Supporting articles are provided in a separate reference list.

Case-reports

There are significant ways that power seat elevation is utilized and beneficial for an individual which may not be represented in peer-reviewed literature. However, this does not take away from the importance of what can be learned from a person's lived experience. This document will include real-life practical examples of the impact that power seat elevation can have on independence, participation, communication, and social acceptance. In the case reports provided in this document, the positive impact of power seat elevation spans many age groups, medical diagnosis, and societal roles.

ICF framework

When matching the right assistive technology to the person who will be using it, there are a multitude of factors that can influence the decision. Factors may include the person's previous experience, the device that fits best with their transportation, or how it improves the ability to complete daily activities with less pain. There is a comprehensive way to include such considerations, which is from the International Classification of Functioning, Disability and Health (ICF) framework. The ICF was developed by the World Health Organization (WHO) to shift discussions from a medical model focused on diagnosis and disability to one highlighting the social model with function as its primary purpose. According to the WHO, ICF creates a standard language to describe health and health-related states.

In "ICF: A Hands-On Approach for Clinicians and Families", the editors state "The ICF framework is a tool to expand our thinking and actions across all dimensions on the field of healthcare providing more rich opportunities to rethink and improve". The ICF framework can be used in many different ways, but the main purpose is as a tool when making decisions around health plans and health policies. This supportive statement look at the impact of power seat elevate alongside the ICF framework as it relates to important areas of a person's everyday life related to body functions and structures, activities, participation, environment, and personal factors. The framework has been adapted to also include quality of life (McDougall et al. 2010).

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