Design of a low-cost, reconfigurable, standing wheelchair with easy and stable sit-stand-sit transition capability

# Supporting Information

## Translation from concept to market

In SWC version-1, the link lengths and gas spring specifications were calculated for an average user's weight and height. The SWC was successfully tested by non-disabled users. The SWC version-2 was aimed at testing with wheelchair users and hence required incorporation of safety features (knee block, heel restraint, chest support) and adjustability features (variable gas spring position, footrest height, seat depth). The adjustability features ensured that users maintained a biomechanically correct posture in the standing position. Also, the handle shape was modified to improve ergonomics, reachability, and user convenience. Most wheelchair users could operate the standing functionality with ease after the gas spring location, and wheelchair dimensions were adjusted to their height and weight.

The SWC versions-1, 2 had a four-wheel chassis. All later SWC versions used a three-wheel chassis to reduce mechanical complexity and improve stability on uneven outdoor terrain. Apart from the three-wheel chassis, SWC version-3 included a rigid backrest for better support and propulsion, a folding backrest for portability, fixed (height adjustable) footrest to reduce complexity. Wheelchair users could use the standing functionality with ease and comfortably propel the wheelchair on rough terrain in rural areas. In SWC version-4, the footrest angle was modified to correct the standing posture. Other improvements included minimal backrest allowing functionality, adjustable lumbar cushion for better support, concentric handle with wheel, ergonomic knee block, and dip to allow easy entry and exit.

The SWC version-5 incorporated industrial design inputs to improve ergonomics, usability (removable knee block, hybrid handle, foldable armrest, split footrest), aesthetics, and design principles for manufacturability and assembly. Overall, the latest SWC version provides standing functionality with ease of operation, safety locks, outdoor mobility, affordability (ex-factory price INR 15000 in India; around USD 210), customisability, and is aesthetically pleasing. A one-time fitting and training by a trained medical professional ensure optimal operation and a comfortable user experience. Over 100 wheelchair users provided feedback on the SWC after a hands-on experience. The commercial product, Arise, was launched in November 2019 by the industry partner, demonstrating a success story of the GRID model (Sujatha et al., 2019) in translating assistive product concepts into the market.

## User experience study

Thirty participants (*N* = 30, 25 Male, 5 Female; all with spinal cord injury) were recruited for the user experience (UX) study. The UX study was conducted over six weeks (five participants per week) within the hospital premises under the supervision of clinical personnel. The personnel took participant anthropometric measurements, and chose a suitable SWC size. Next, the SWC was adjusted for each participant to achieve proper fit.

The study started with a 30 min training session that involved thirteen activities. The participants were then allowed to use the SWC independently within the hospital premises. A handout containing lists of recommended activities and Do’s-Don’ts was given and explained to the participants. Over the study period, the participants were encouraged to perform twenty-two activities to familiarise themselves with the SWC. The participants were also trained to perform four functional usage activities with the SWC. At the end of the study, the participant responses to ten outcome measures were captured using a 5-point smiley-based Likert-scale questionnaire.

There were no falls or major adverse outcomes reported during the UX study. The one-time fitting and interactive training session ensured optimal effort for SWC operation, correct posture, and comfortable user experience. All participants were able to operate the manual standing mechanism using the handle knobs. Most participants (around 87%) felt that the standing mechanism was easy to operate and felt safe while standing in the SWC. About 67% participants were very satisfied with the ease of propulsion of the SWC. About 70% participants were very satisfied with the seating comfort of the SWC. Majority participants (93%) felt happy when they stood in the SWC. Around 77% participants felt very confident while talking to others in the standing position. About 83% participants preferred the SWC over their current wheelchair. Furthermore, 80% participants anticipated that they could accomplish more at home using the standing function of the SWC.

## SWC videos, user measurement guide and forms

The videos of initial versions of the SWC are available at <https://bit.ly/38Op3y0> (Version-0 SWC) and <https://bit.ly/36BPlSz> (Version-1 SWC). A video from the user experience study of SWC is available at <https://bit.ly/2RBc50P> (Version-5 SWC). The product promotional video of the Arise SWC is available at <https://r2d2.iitm.ac.in/resources/arise-standing-wheelchair> (Version-5 SWC).

The Arise SWC awareness video is available at <https://r2d2.iitm.ac.in/resources/arise-standing-wheelchair>. The video would be useful to potential users of the Arise SWC or medical professionals interested in prescribing Arise as it attempts to answer the following questions:

* What are the features and benefits of the Arise SWC?
* Who is the Arise SWC suitable for?
* What is the assessment procedure to be followed to determine the suitability of the Arise SWC?
* How is the fit of the Arise SWC determined?
* How can the Arise SWC be customised for the user?
* What are the safety features of the Arise SWC?
* How do you check that the Arise SWC has been properly fitted to the user?

The user measurement guide and forms required by medical professionals to determine the suitability, prescribe, check out the fit, and training for Arise are available at <https://r2d2.iitm.ac.in/resources/arise-standing-wheelchair>.

# References

Sujatha, S., Bapat, G. M., & Dash, S. S. (2019). GRID: a model for the development of assistive devices in developing countries. *Disability and Rehabilitation: Assistive Technology*, 1–7. https://doi.org/10.1080/17483107.2019.1673838