ORIGINAL ARTICLE

Comparison Between A Tilt-in-Space Wheelchair and a Manual Wheelchair Equipped With a New Rear Anti-Tip Device From the Perspective of the Caregiver

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ABSTRACT. Kirby RL, MacDonald B, Smith C, MacLeod DA, Webber A. Comparison between a tilt-in-space wheelchair and a manual wheelchair equipped with a new rear anti-tip device from the perspective of the caregiver. Arch Phys Med Rehabil 2008;89:1811-5.

Objective: To test the hypothesis that, in comparison with a commercially available tilt-in-space wheelchair, a lightweight manual wheelchair equipped with a new, rear anti-tip device (Arc-RAD) provides caregivers with improved wheelchair-handling performance, less exertion, and greater satisfaction.

Design: Within-participant comparisons.

Setting: Rehabilitation center.

Participants: Able-bodied participants (n=19) simulating caregivers and simulating wheelchair users (n=7).

Intervention: Caregiver participants were trained (50–75min) in wheelchair-handling skills.

Main Outcome Measures: Each participant was tested in both wheelchairs, in random order. To evaluate wheelchair-handling skills, we used the total percentage score on the Wheelchair Skills Test (WST), version 3.2. For exertion, we used a visual analog scale (in percent). For satisfaction, we used the Quebec Users' Evaluation of Satisfaction with assistive Technology (QUEST; range of values, 8–40), version 2.

Results: Mean percentage WST scores ± SD for the Arc-RAD and tilt-in-space wheelchairs were 95.9%±4.2%, and 91.9%±4.8%, respectively (P=.008). The mean perceived exertions during Arc-RAD and tilt-in-space wheelchair use were 26.1%±20.4% and 46.6%±23.2% (P=.003). The mean total QUEST satisfaction scores for the Arc-RAD and tilt-in-space wheelchairs were 35.1±3.8 and 28.4±4.7 (P=.002).

Conclusions: In comparison with the larger and heavier tilt-in-space wheelchair, a lightweight manual wheelchair equipped with a new rear anti-tip design allows 4.4% better wheelchair-handling performance, 44% less exertion, and 23.6% greater wheelchair satisfaction.

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A commercial party having a direct financial interest in the results of the research supporting this article may confer a financial benefit on the author or one or more of the authors. Kirby holds a U.S. patent on the device that is the focus of this study; it may be commercialized in the future.

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TILT-IN-SPACE WHEELCHAIRS allow wheelchair users to tilt backward without altering their posture (joint angles). The tilt-in-space feature is available for both powered and manual wheelchairs. People requiring manual tilt-in-space wheelchairs tend to be less active and to require caregiver assistance for their mobility.

Tilting a wheelchair user backward has an advantage over reclining it (when the backrest angle increases, but the seat angle does not) of reducing shear forces between the user and the wheelchair.[1] Depending on the extent of tilt, the tilted-back position has been variously reported to improve comfort, improve sitting balance, improve breathing, reduce sitting pressures, reduce spasticity, increase the biomechanic efficiency of wheelchair propulsion, and improve catheter drainage.[2-7] However, manual tilt-in-space wheelchairs tend to be larger, heavier, and more costly than other manual wheelchairs.[5]

Pilot work has suggested that a new rear anti-tip device,[8,9] the Arc-RAD (so-named because the anti-tip arm, out of the way at rest, self-deploys through an arc when needed), on a lightweight manual wheelchair could replace the tilt-in-space function. In the tilted-back position with the Arc-RAD, the wheelchair user can rest without support. The caregiver can use the tilted-back position to perform skills (eg, curb ascent) requiring the casters to be off the ground. If a lightweight wheelchair fitted with Arc-RADs could duplicate the tilted-back position of tilt-in-space wheelchairs without any loss of functionality, this option might achieve the benefits of the tilted-back position without the extra size, weight, and cost of the tilt-in-space wheelchairs.

The purpose of this study was to test the hypothesis that, in comparison with a commercially available tilt-in-space wheelchair, a lightweight manual wheelchair equipped with Arc-RADs provides caregivers with improved wheelchair-handling performance, less exertion, and greater satisfaction.

List of Abbreviations

Arc-RAD	new rear anti-tip device
C-RAD	conventional removable rear anti-tip device
QUEST	Quebec Users' Evaluation of Satisfaction with assistive Technology
VAS	visual analog scale
WST	Wheelchair Skills Test

METHODS

Participants

We studied 20 participants, a sample of convenience consisting of university students and hospital staff. Using the variability data from a previous caregiver study,[10] a target minimum effect size of 20%, a power of .90, a 2-sided matched-pairs *t* test, and an α of .05 for the power analysis, the estimated sample size was 8. We increased the sample size to 20 to obviate any difficulties due to greater variability than predicted. In addition to the caregiver participants, we used 7 participants as wheelchair occupants. Given the pilot nature of this study and the focus on caregivers, we elected to study able-bodied participants without prior wheelchair experience. Subjects were recruited through word of mouth and screened by self-report. All participants were 17 years of age or older, had body sizes that fit the wheelchairs being tested (if a wheelchair occupant), were able to follow instructions and had no unstable medical conditions. Demographic data (age, sex, height, weight) were collected from all participants.

Ethical Issues

This study was approved by the Research Ethics Board of the Capital District Health Authority. All participants provided informed consent.

Wheelchairs

The Arc-RAD wheelchair was a lightweight, rear-wheel-drive model (fig 1).[a] No headrest was used because it was unnecessary for the wheelchair-handling skills. A pair of prototype Arc-RADs was attached to the rear frame of the wheelchair and adjusted for the occupant.[9] The wheelchair, including Arc-RADs and foam cushion, weighed 20.9kg and had an overall length of 96.5cm. The tilt range of the Arc-RAD wheelchair was 0° to 40°. In a recent study of tilt-in-space powered wheelchairs, using dataloggers, Sonenblum et al[11] found that the majority of tilts did not exceed 40°.

We chose the representative tilt-in-space wheelchair (Orion II)[b] (fig 2) after a review of available data from the manufacturers of 16 commercially available tilt-in-space wheelchairs.

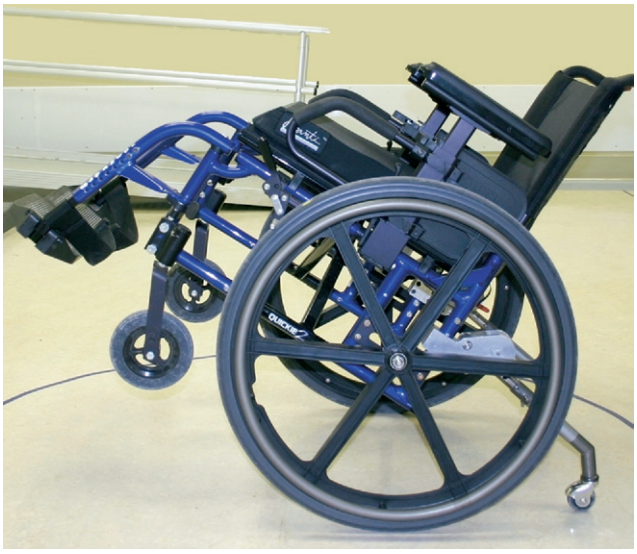

Fig 1. The Arc-RAD–equipped wheelchair, tilted back and resting on the Arc-RADs. The casters are off the ground.

Fig 2. The tilt-in-space wheelchair, tilted back. The casters are on the ground and the conventional rear anti-tip devices are off the ground.

C-RADs were attached to the rear of the frame. The wheelchair, including the contoured cushion (Prism Supreme II),[b] weighed 41.3kg and had an overall length of 114cm. The tilt range of the tilt-in-space wheelchair was 0° to 45°.

Training

Participants were trained as caregivers in pairs, using the Wheelchair Skills Training Program.[12] Participants were first introduced to the features and functions of the 2 wheelchairs and their components. Then, one of the participants, chosen randomly, simulated the wheelchair occupant while the other learned the wheelchair skills as a caregiver. Then, the wheelchairs were switched and the process was repeated. The caregivers were permitted to adjust the wheelchairs to complete the skills. This included the removal or repositioning of the C-RADs on the tilt-in-space wheelchair. The training was considered complete when the trainer and participant were satisfied with all skills for both wheelchairs. Then, the caregiver switched places with the wheelchair occupant and training was repeated. The mean training time was 58 minutes (range, 50–75min) on a single occasion for the pair of participants.

Outcome Measures

For wheelchair-handling performance, we used the total percentage score on 53 caregiver-relevant skills of the WST, version 3.2.[12] The measurement properties of the WST have been reported[13] and the WST has been used in a number of previous studies as an outcome measurement,[14-16] including for caregivers.[10] The tester was blind to how participants had performed during training, but the wheelchair condition could not be masked.

For perceived exertion, we used a VAS (in percent). Participants were asked "How would you rate your exertion as you performed the Wheelchair Skills Test?", responding by marking a point on a 100-mm line, with 0mm labeled as "no exertion" and 100mm labeled as "maximum exertion."

For satisfaction, we used the QUEST, version 2.0,[17] specifically the 8 components for assistive devices (dealing with dimensions, weight, ease of adjustment, safety and security, durability, ease of use, comfort, effectiveness). For each of the 8 components, participants rated the wheelchairs with a score