

Midi-Rox: A reversible wrap dress to empower one-handed dressing

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Abstract: Disability prevalence and the need for assistance increases with age. Rising trends in the global aging population will multiply the number of the people impacted by disability. The lack of adequate accessible apparel for persons with disabilities (PWD) exacerbates disablement and barriers to community participation (1). In fellowship with Open Style Lab, an interdisciplinary team researched materials, technologies, and design solutions that enhance accessibility to functional clothing for PWD. Our client-centered design originated in collaboration with a person disabled in the activity of dressing due to hemiplegia caused by a Stroke. A closure-less garment design and compensatory dressing strategy were developed to minimize caregiver assistance for persons limited to one-handed dressing. The Midi-Rox dress and Hemi-Wrap method promote safety and modified independence.

Keywords: open style lab, one-handed dressing, stroke, midi-rox, hemi-wrap, occupational therapy, accessible design, adaptive clothing, aging and disability.

User & User Scenario

Roxinne is a 70 year old African-American female and retired Psychologist. She worked at the NY State Department of Health for over 25 years. She enjoyed teaching Psychology courses and speaking at motivational and religious events. Her past medical history includes Cerebrovascular Accident (CVA), or Stroke, and Hypertension (HTN). A stroke occurs when brain cells die from lack of oxygen, usually caused by a blocked artery or ruptured blood vessel. When brain cells die, normal functions controlled by that region of the brain become impaired. Stroke is the leading cause of long term disability in the United States and one of the leading causes of disability worldwide (2). Hypertension (HTN) is a medical condition in which blood pressure in the arteries is constantly elevated. HTN, or high blood pressure, is the single most important risk factor for stroke, according to the American Heart Association (3).

For Roxinne, the stroke impaired regions of her brain responsible for math & scientific analysis, task-specific sequencing, and memory skills, which made it impractical to resume her career. The stroke also caused hemiplegia, or paralysis, on the right side

of her body. Roxinne became disabled to complete activities of daily living (ADL) such as dressing, bathing or feeding without assistance from a caregiver, disrupting her personal and social lifestyle. According to the Modified Rankin Scale for measuring the degree of disability or dependence in the daily activities of people who experience a stroke, Roxinne has a level 4 (out of 5) moderately severe disability. She currently resides in the long term care community at Riverside Premier Rehabilitation & Healing Center, in Manhattan, NY.

Design Requests

Roxinne, or Roxie, was dissatisfied to wear what she identified as “plain & oversized clothing typically worn by disabled people,” since they did not reflect her personality or professionalism. She requested a mid-length dress with vibrant colors for attending social occasions. Stating, “nothing raises my blood pressure more than waiting for someone to help me get dressed,” she emphasized a goal to reduce her dependence on caregiver assistance when dressing. She also suggested a design with minimal closures, or closures easily manipulated with one hand.

DESIGN ELEMENTS

I. Reduce caregiver assistance

Roxie has difficulty standing and maintaining her balance due to paralysis in her right arm, leg and trunk musculature. She requires 75% assistance from caregivers to stand from, pivot towards, and be seated onto another surface, as when moving to and from her bed and wheelchair. Unable to safely support her balance and simultaneously manipulate clothing, Roxie and her caregivers prefer she mostly dress and undress while seated in her wheelchair to reduce the risk of falling or injury to either party. In 2016, healthcare providers had the highest reported cases of non-fatal occupational injuries according to the Bureau of Labor Statistics most recent Survey of Occupational Injuries and Illnesses (4). Data collected from the Upper/Lower Body Dressing components of the Functional Independence Measure (FIM) indicated that caregivers perform between 75-100% of the components required to fully clothe and undress Roxie, in order to save time, promote safety, and conserve energy. These performance and safety considerations were assimilated into our design by proposing strategies that would allow one-handed dressing and undressing to be completed from a seated position.

Individuals with upper extremity impairments are trained by occupational therapists in rehabilitative and/or compensatory strategies to resume functional activity. Rehabilitative strategies aim to restore lost functioning while compensatory strategies aim to adapt procedures, devices and environments to resume participation in activities of daily living. Although rehabilitative strategies to restore lost function were reinforced over the 10-week design process, our mission was to investigate adaptive strategies to improve performance in the activity of dressing. Since Roxie is unable to step into or pull up clothing due to impaired balance and use of her right arm, we disregarded compensatory strategies that began the dressing process from the lower body. The Overhead and Over-the-Shoulder methods are two compensatory strategies for dressing upper body

clothing such as a sweatshirt or jacket. We theorized that putting on a dress like a sweatshirt, using the Overhead method, required either significant trunk and pelvic shifting, some degree of standing, and/or bimanual manipulation of the dress past the waistline, and was therefore excluded from our initial design consideration. In contrast, a jacket can be put on (donned) or taken off (doffed) while seated. Accordingly, our first prototype was predicated on utilizing the Over-the-Shoulder method of compensatory upper body dressing to eliminate the need for standing and risk of falling or injury. The Over-the-Shoulder method entails using the non-paralyzed arm to guide a jacket sleeve over the paralyzed arm and shoulder first. Holding the neck collar, the jacket is then guided around the backside before placing the non-paralyzed arm through the armhole and sleeve.

After seated and standing body measurements were taken, our designer created a mid-length, jacket-style prototype in muslin, a plain-woven cotton fabric to initiate testing with Roxie. We envisioned the dressing process to begin with caregivers placing the dress within the wheelchair, neck collar draped over the backrest and the sleeves draped over the armrests of her wheelchair. With the outside of the dress facing down, Roxie could sit atop her dress within the wheelchair and begin one-handed dressing (See figure A). She need only guide her arms through the sleeves before overlapping the front panels to complete dressing. In this manner, caregivers would have the convenience to set out the dress in advance. Positioning the dress behind and underneath Roxie would also eliminate the need for assistance to maneuver the dress around her backside, effectively removing one step of the Over-the-Shoulder method.

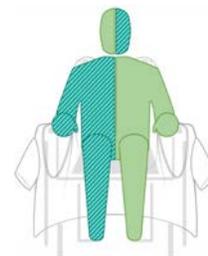


Figure A.

Following a stroke, individuals with hemiplegia are taught by occupational therapists that impaired extremities get dressed first, and undressed last. This one-handed work simplification and energy conservation strategy is akin to executing the most difficult components of a task first. Admittedly, Roxie had difficulty recalling this vital dressing strategy previously learned in rehabilitation. In error, she would repeatedly attempt to dress her left side first, resulting in more time, effort and assistance to complete dressing.

After constructing and testing our initial prototype, further data collected from the Nottingham Stroke Dressing Assessment (NSDA), along with video analysis, revealed that Roxie had improved performance using the Overhead method compared to the Over-the-Shoulder method of dressing her upper body. Specifically, reduced time, effort, and assistance were recorded. Over numerous trials, it became evident that donning a shirt by first placing the neck collar overhead was a more intuitive behavior for Roxie to initiate, as opposed to dressing her impaired side first. She also displayed significant ease when locating the neck collar of a shirt compared to the armhole in the sleeve. Placing the garment overhead first created a draping of the fabric that naturally expanded the armhole. This sequence provided a static target location which required less effort to approximate and guide her arm through the sleeve. Surprisingly, after the garment was overhead, Roxie exhibited a tendency to correctly dress her impaired side first. These results appeared to nullify our initial design hypothesis of utilizing an Over-the-Shoulder method of one-handed dressing to reduce the need for standing and caregiver assistance.

II. Minimal closures to manipulate

Most closures are designed for bimanual manipulation and present reduced functionality for users limited to one-handed dressing. Evidenced by low scores in Upper Arm Function and Hand Movement sections of the Motor Assessment Scale, Roxie is unable to use her right arm or hand to perform gross and fine motor coordination tasks

such as reaching and grasping clothes, or manipulating closures like zippers, snaps, buttons, knots or belts. Upper Arm Function and Hand Movement scores in the left extremity revealed within functional limits (WFL) strength, coordination, and range of motion (ROM), indicating all dressing and closures would be completed solely using the left arm and hand. In order to reduce the gross and fine motor coordination constraints of bimanual closures, our team speculated that opposing magnets would be the most simplified manner to fasten/unfasten a dress since general approximation would result in opposing magnets connecting.

We surmised that frontal overlapping panels would best facilitate one-handed dressing by minimizing the range of movement required to connect the magnets, and by maintaining all closures within sight. Magnet locations were determined according to comfort and fit while in a seated position. Three (3) magnets, each 0.75 inch in diameter, were enclosed in a thin plastic casing. The magnet casings were diagonally sewn atop the inner panel of fabric from the left shoulder, to the right chest, and at the right side torso locations (See Figure B). Opposing magnets were sewn at corresponding locations on the inside of the outer, overlapping panel of fabric.



Figure B.

After the prototype was over her shoulders with arms through the sleeves, Roxie demonstrated considerable ease overlapping the panels and connecting the individual magnets using her left hand. However, the disadvantage of using magnetic closures on our design became apparent before this final step.

Prior to dressing, as the dress was being placed within the wheelchair, the magnetic closures consistently attached to the metallic frame of the wheelchair. This obstacle imposed more time and effort to detach the magnets and correctly reposition the dress, often requiring numerous attempts. Regardless of these efforts, after sitting atop her dress, the magnets frequently reattached to other metallic locations on the wheelchair. Attempting to locate and detach the magnets as a precursor to dressing became discouraging for all parties involved. Despite the simplicity and success Roxie demonstrated using this magnetic closure design to complete the dressing process, the preliminary steps of detaching magnets, positioning arm holes, and donning sleeves over the arms and shoulders still required assistance from caregivers. These results appeared to nullify another preliminary design hypothesis suggesting that frontal overlapping magnetic closures would minimize the dexterity constraints for one-handed dressing.

Intuitive Design Solutions

Committed to providing Roxie with an accessible solution that reduced her dependence on caregiver assistance for dressing, we re-evaluated the strengths and weaknesses of our previous designs and Roxie's functional performance. Convinced that modifying those designs and procedures would accommodate shortcomings, another prototype was developed to further assimilate these elements.

We could not overlook the safety risks for both Roxie and her caregivers when standing to dress and chose to maintain the fall prevention strategy of dressing from a seated position. Extracting this modified component from the Over-the-Shoulder method affirmed that caregivers would still set up the dress for Roxie to sit atop. However, to allow for convenient placement within the wheelchair, all magnetic closures would be removed from this prototype. Although Roxie was successful in manipulating the magnets to fasten and unfasten her dress, she continued having difficulty with the

precursory steps when using the Over-the-Shoulder method of dressing. In contrast, when using the Overhead method, she displayed improved performance dressing her upper body by first placing the neck collar overhead, like a sweatshirt, before guiding her arms through the sleeves. Accordingly, we replaced the Over-the-Shoulder method of first guiding the sleeve over the impaired extremity with the Overhead method of guiding the neck collar overhead first. By modifying and combining elements of both the Over-the-Shoulder and Overhead methods, we invented and fabricated a new clothing pattern, the *Midi-Rox* (See Figure C).

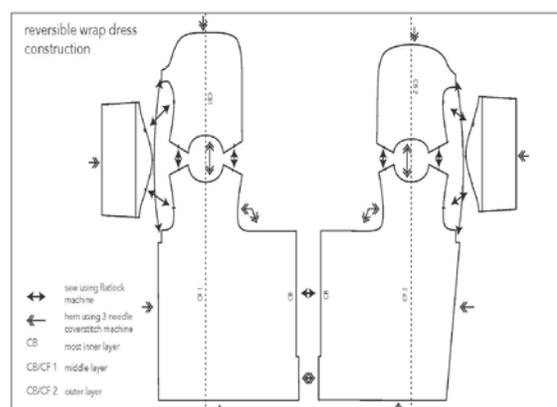


Figure C.

Most notably, our pattern was atypically fashioned with two (2) neck collars on opposing sides. This unconventional attribute was the step forward to eliminating magnetic and all closures on the dress. Building on the *Midi-Rox* pattern, we further developed an innovative, one-handed compensatory dressing method, the *Hemi-Wrap* (See Figure D). In conjunction with the *Midi-Rox* dress pattern, the *Hemi-Wrap* method of dressing and undressing was specifically designed to enhance Roxie's functional abilities by accommodating her intuitive dressing behavior.

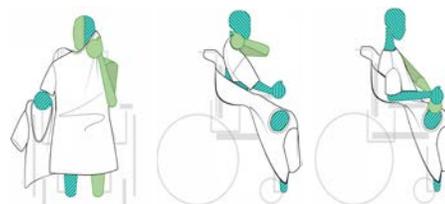




Figure D.

Our designer constructed a prototype from our new technical pattern in a jersey knit fabric. Although this soft fabric was excellent for replicating a flowing dress, it would knowingly become overstretched after a few trials. We only required the perspective to validate or refute the Midi-Rox pattern and Hemi-Wrap method were practical solutions to functional clothing. Prior to, and during trials, Roxie was instructed in the Hemi-Wrap dressing method using verbal directions, visual demonstrations, and hand-over-hand sequencing to facilitate carryover. We began trials by positioning the dress within the wheelchair, outside facing down, and the sleeves draped over the arm rests. However, the Midi-Rox closure-less pattern emphasized the bilateral neck collars being placed over the front end of each arm rest for easy location and acquisition (See Figure E).



Figure E.

After sitting atop her pre-positioned dress, Roxie began the Hemi-Wrap method of one-handed dressing. Using her left hand to grasp the neck collar located on the left armrest, she instinctively placed the neck collar over her head. With assistance from her free left hand, Roxie effectively positioned and guided her right arm through the draping armhole

and sleeve. Somewhat imperceptible to Roxinne, she had just completed the vital therapeutic strategy of dressing the impaired extremity first. Repeating this 3-step sequence to now dress her left side, Roxie grasped the neck collar positioned on the right armrest and placed the second neck collar over her head. Without difficulty, she was able to guide her non-paralyzed left extremity through the draping armhole and sleeve to complete the dressing process. Directing the neck collar and sleeve from one side of the wheelchair to dress the opposite side of the body produced a frontal, overlapping wrap-style dress. After eight (8) trials Roxie could properly sequence the Hemi-Wrap method of dressing with only verbal instruction, significantly reducing the amount of assistance required to dress herself.

Following each dressing trial, Roxie was instructed in the Hemi-Wrap undressing method using verbal directions, visual demonstrations, and hand-over-hand sequencing to facilitate carryover. This method entailed grasping and removing the last neck collar placed overhead before withdrawing the left arm from the sleeve. Identical in process, Roxie then grasped and removed the first neck collar placed overhead before assisting the withdrawal of her impaired right extremity from the sleeve. Appropriately, the Hemi-Wrap method also reinforces the therapeutic strategy to undress the impaired extremity last. Furthermore, Roxie was independently able to reposition the neck collars over their corresponding armrests on her wheelchair, essentially positioning the dress to be donned again. After six (6) trials, Roxie could independently sequence the Hemi-Wrap method to undress herself.

III. A vibrant dress for social occasions

Before constructing a mid-length dress for Roxine (Midi-Rox), our designer researched fabric qualities that prioritized function into the design. By utilizing high-stretch fabric, we were able to expand the error tolerance when donning and doffing the neck collars and sleeves. This feature would also accommodate changes in body size or posture over time and easily contour around any undergarment.

Since Roxie is seated throughout most of the day, choosing a breathable material with superior moisture-wicking qualities was essential for personal comfort and hygiene. It was equally important to utilize material with easy care instructions to minimize time and cost of cleaning. After reviewing numerous material characteristics, we selected the Polartec® Power Grid™ double-sided knit jersey (See Figure F). Inclusive of the aforementioned elements, this material has a slight melange weave on one side and grid texture on the opposite which provides variation of style for different occasions.



Figure F.

Practically symmetrical by design, the Midi-Rox closure-less dress is also reversible, allowing Roxie the benefit of two dresses from one garment. Dress, because it may be seen in social encounters before conversation can be initiated, has a certain priority over discourse in the establishing of identity (5). Empowering her desire for self-expressive clothing, Roxie chose a color combination of Teal on one side and Kiwi on the reverse to accentuate her Spring through Fall wardrobe. The reversible dress required a flatlock stitch to create flat seams on both sides of the dress for preventing skin chafing and irritation. To complement the high stretch fabric, all seams were decoratively sewn with a cobalt blue wooly nylon stretch thread. A wide scoop neckline was incorporated to accommodate Roxie's long, thick dreadlocks when donning and doffing the neck collars overhead. A slight vent on the back hemline was also added to help caregivers easily center the dress within the wheelchair.

Our designer cut and crafted the Midi-Rox dress according to the technical pattern and Roxie's body measurements to achieve a custom tailored fit.



Technology Considerations

In the chronic stroke population, balance impairment and fall risk are associated with lower quality of life (QOL) scores (6). Individuals with hemiplegia often have difficulty maintaining postural control and balance due to weakness in the trunk, arm, and leg musculature. In an effort to help Roxie identify and correct her postural imbalance when sitting or standing, we investigated technological solutions to facilitate awareness and self-corrective behavior. Our engineer programmed degrees of limitation for postural deviations into an Arduino Metro Mini board. Using conductive thread, a light-emitting diode (LED) was connected to the mini board. We proposed attaching the mini board and LED on Roxie's dress to signal when her trunk posture deviated from the pre-set parameters. The blinking LED would notify Roxie of postural asymmetry and prompt self-corrective action. Despite the potential value to identify and correct postural asymmetries, these technologic aspects were excluded from our final design as Roxie was disinterested to incorporate any "gadgets" into her dress.

Conclusion

The Midi-Rox pattern and Hemi-Wrap method of one-handed dressing validated our approach to minimizing the restrictions of clothing fasteners and caregiver assistance. Accommodating intuitive behaviors through rehabilitation sciences and adaptive design can significantly enhance functional performance and safety when dressing. Improving accessibility to stylish clothing for persons with disabilities can reduce barriers to self-expression and meaningful participation in society. Further research is warranted to determine the effectiveness of the Midi-Rox design and Hemi-Wrap methods as equitable use solutions for non-stroke populations disabled in the activity of dressing.

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