

RESNA Design Brief

Problem Statement and Background

Getting dressed is recognized as a basic activity of daily living. In Western societies, dressing independently is culturally valued (Clark et al. 1997). Self-sufficiency in dressing is often a concern for individuals with physical/mobility disabilities (CAOT 2016; Walker et al., 2003). Our research team identified that there is a noticeable paucity of adaptive dressing aids on the market today to assist individuals with dressing brasiers (or bras). Through our team's professional experience, we observed how persons living with one functional arm due to chronic conditions such as arthritis, stroke, and amputation frequently encounter difficulties in dressing bras. Currently, there are only two existing devices on the market, the [Bra Buddy®](#) and [BraAngel®](#) which address this issue. While these products are available to the public, the reviews of these two products are largely negative (Appendix C). The lack of diverse options for assistive dressing devices for bras may be attributed to the historical absence of women in research and design (Liu & Dipietro-Mager, 2016), or the prevalent social stigma individuals with disabilities face regarding sexuality and autonomy (Esmail et al., 2010; Wang & Dovidio, 2011; Amosun et al., 2013). The end result is a notable lack of adequate and effective dressing aids for individuals with physical/mobility challenges in dressing a bra. Our product attempts to fill this gap, by providing persons with physical/mobility challenges with an assistive device that is affordable, accessible, and overall superior in facilitating the dressing of a bra with one functional arm.

Methods, Approach, and Solutions Considered

Our team conducted a hierarchical task analysis (HTA), tabular task analysis (TTA), subjective analysis (SA), and anthropometric analysis (AA) to inform the design criteria. Based on these criteria, a weighted decision matrix was used to evaluate ideas and determine a final design concept for our prototype.

Analysis:

- 1) **Hierarchical Task Analysis** (Appendix A): A HTA was conducted to analyze the performance of dressing a bra in a hierarchical manner, by breaking down this greater goal into smaller sub-goals or tasks in their correct sequence. This helped us to identify the sub-tasks that cause the most difficulty in terms of dressing performance for our target population, and narrow down the preferred ways of dressing a bra with one arm/hand from the perspective of our intended users.
- 2) **Tabular Task Analysis** (Appendix B): A TTA was conducted in collaboration with our sample representative, 'S'. TTA is a method of analysis that expands upon the data gathered from the HTA, by breaking down the activity of dressing a bra into its constituent elements and describes the various properties involved in the completion of each task or sub-task (Wang, 2020). TTA enabled our group to identify the possible barriers affecting the performance of dressing a bra for S. We identified the following variables to be analyzed in a greater depth: time/duration, physical, sensory/perceptual, cognitive, affective, and environmental demands. Identifying the demands and barriers supported the development of design criteria for the current assistive device.

- 3) **Subjective Analysis** (Appendix C): We utilized SA to collect data from our user's experience/perspectives, design preferences, demands, and initial impressions associated with the device that is to be designed. Our SA consists of two components (which were answered by our sample client, S.):
- a) *Questionnaire*: 15 questions designed to learn about client needs. Our sample representative S completed this questionnaire. She identified that ease of fastening and ease of wrapping around the waist were the most important design criteria because they are associated with decreasing pain and energy expenditure. Further, portability, compatibility with different bra types, cost, comfort, and durability were identified by S to be important standards incorporated in a final bra aid.
 - b) *User experiences with existing bra devices*: Three online retailers were selected: Amazon, AllegroMedical and Arthritis Supplies. Customer reviews regarding BraBuddy® and BraAngel® were analyzed. Shared weaknesses were identified, including: 1) Not compatible with different types of bras 2) Poor durability and quality (material) 3) Discomfort 4) Large energy expenditure for use 5) Difficulty to fasten.

4) **Anthropometric Analysis**: Our research group utilized anthropomorphic databases such as the ANSUR II, the NHANES and the Canadian Health Measures Survey to target relevant data for female adults (ANSUR II, n.d; NHANES, n.d.). The data from our AA served as a guide for sizing of the device (e.g. waist measurements of average populations). This data was helpful in the future development of our *SlapBra* to accommodate for different sizes of waist circumferences, in order to design an inclusive device.

The culmination of our analyses of HTA, TTA, SA and AA informed our final design criteria. Our definitive design criteria included: *Ease of fastening, Ease of wrapping around waist, Ease of reset, Cost, Portability, Lightweight, Durability, Comfort, Compatibility with different bra sizes/types.*

Design Alternatives and Selection Process

Four solution concepts were considered and evaluated: *Slap Band, Detachable Magnets, Tabs on the Wall, Belt with Two Tabs.* A weighted decision-matrix was utilized to select a final design concept based on the aforementioned design criteria.

Weighted Decision-Matrix (Appendix D)

We prioritized the criteria *Ease of fastening* and *Ease of wrapping* around waist at 20% each, as these scales represented the core functional tasks our prototypes must address. Secondly, we ranked *Ease of reset* and *Compatibility for different bras* at 15% each, as we determined these requirements were essential in designing an assistive device that is adaptable for existing bras. We rated the criterion of *Cost* at 10%, as we intended our device to be affordable for those who require it. Lastly, we assessed *Portability, Lightweight, Comfort, and Durability* at 5% each, since we considered these criteria as ideal, but not essential requirements for our effective prototype design. Each team member independently scored the weighted decision matrix for each design concept, and scores were averaged. The *Slap Band* design concept was determined to be our final solution concept.

Final Approach and Design

The *Slap Band* design concept was chosen to be our final prototype idea based on the aforementioned weighted decision matrix. This concept centers around the unique properties of slap bands, which were popularized as children's slap bracelets in the 90s. When slapped

onto the wrist, these silicone bracelets grab on and wrap around the wrist instantly. This feature stood out to us because it provides ease of wrapping, which was found to be of great importance from our sample participant. Thus, the slap band design concept uses the slap band as a mechanism to wrap the bra around the user's waist.

Our prototype utilizes a larger slap band for ease of wrapping around the waist. The larger slap band we found for use in our prototype is a yoga mat slap band, a product meant to keep yoga mats in a rolled position. Although this works for our prototype, later iterations will include various sizes for different body types. To attach the bra onto the band, we designed and created tabs made of thermoplastic. Velcro materials were then used to adhere the tabs onto the band. We decided to name our device the *SlapBra*.



The instructions for the use of the *SlapBra* are as follows:

<https://drive.google.com/file/d/1eKzpQrQr2vKtf2TJ-VDXpBxEpAfbBubE/view?usp=sharing>

1. Unroll the *SlapBra*
2. Hook the two ends of the bra onto the tabs
3. “Slap” the device onto their waist, which will result in both the *SlapBra* aid and the bra to be wrapped around their body
4. Fasten the bra
5. Remove the bra from the *SlapBra* device
6. Twist the bra until the clasp is behind them
7. Put the bra straps on

Outcome

We value future users’ feedback and understand their perspectives towards the prototype are important to develop a functional assistive device. Our target population are individuals with one functional arm who want to put a bra on independently. Efforts were made to recruit the target population through liaising with potential organizations and disability services. Due to the restrictions of COVID-19, responses to our recruitment emails were low. We were unable to find individuals living with one functional arm to review our current prototype iteration. Unfortunately, our sample representative S was unavailable. Thus, the prototype was examined and evaluated through three model clients (our team members).

The model clients, who are able-bodied, attempted to not use one of their arms in order to simulate the lived experience of individuals living with one functional arm. Although the simulation of the task to put on a bra using one arm by our model clients is not fully reflective of the lived experience of the target population, it is the most feasible approach due to the COVID-19 restrictions. Further research can be conducted with the prototype being evaluated by the target population to gain valuable feedback from individuals living with one functional arm.

Through the feedback of three model clients, we identified the following project goals have been achieved.

- Ease of fastening the bra hooks and eyes with one hand
- Ease of wrapping the bra strap around the waist with one hand
- Portability and ease of carrying around
- Low cost of production
- Durability

We also recognized the potential area that can be improved for future iterations of our device. Since we utilized a slap band that is designed to fasten a yoga mat, the sizing of the slap band is relatively short to a human waist. We have contacted the manufacturer of the slap band to inquire about the possibility of producing different sizes of the slap band. Our team aims to create more accurate and inclusive versions of our design.

Cost

Cost is one of the important design criteria during prototype development. The *SlapBra* has been designed to be affordable for potential users, and become the gold standard assistive device for dressing a bra. The total cost of materials and different parts of the prototype is US\$ 20. More details are displayed in Table 1.

	PROTOTYPE PRICE (US\$)
MATERIAL (THERMOPLASTIC)	6
PARTS: SLAPBAND; VELCRO	12 2
TOTAL	20

The estimation in the above table disregards the potential labour cost associated with assembling different parts. Also, the attaching tab on the final prototype was handmade by the group/research team using thermoplastic. Therefore, there is no cost associated with manufacturing the tab. In order to estimate the cost of manufacturing a bulk amount of tabs, we conducted massive research and also inquired multiple manufactures for a quote. The projected cost of producing the tab would be approximately \$6-\$20 per prototype.

Significance

Our research team developed the *SlapBra* design prototype in collaboration with a sample representative S to enable individuals with one functional arm to independently put on a bra. Through the performance of four types of analyses (HTA, TTA, Subjective analysis and Anthropometric analysis), we were able to achieve 5 of our 9 design requirements (*Ease of fastening, Ease of wrapping around waist, Cost, Portability, and Durability*) that guided the development of our current prototype iteration for our target population.

Our *SlapBra* design significantly improves quality of life for our device users. Our prototype design enables individuals with one functional arm to easily dress a bra with minimal effort. Enabling our users to independently dress intimate clothing provides our prospective customers with a sense of autonomy and fulfillment, improving self-esteem. By closely collaborating with our sample population representative (S), our device avoids all of the pitfalls of existing bra dressing aids on the market, by incorporating users' reviews and recommendations directly from the source. We intend for our assistive dressing device to become the optimal choice for our targeted population. Future steps include the manufacture and testing of multiple-sized *SlapBra* devices to receive greater feedback from our target population, in order to develop the best- and most client-centered assistive dressing aid for bras available on the market.

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Appendix A: Hierarchical Task Analysis

Figure 1

HTA: Dressing a Bra with Two Functional Arms

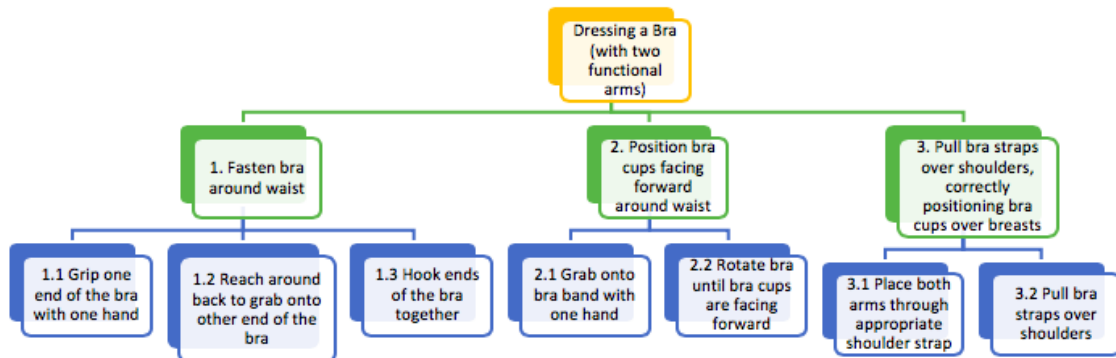
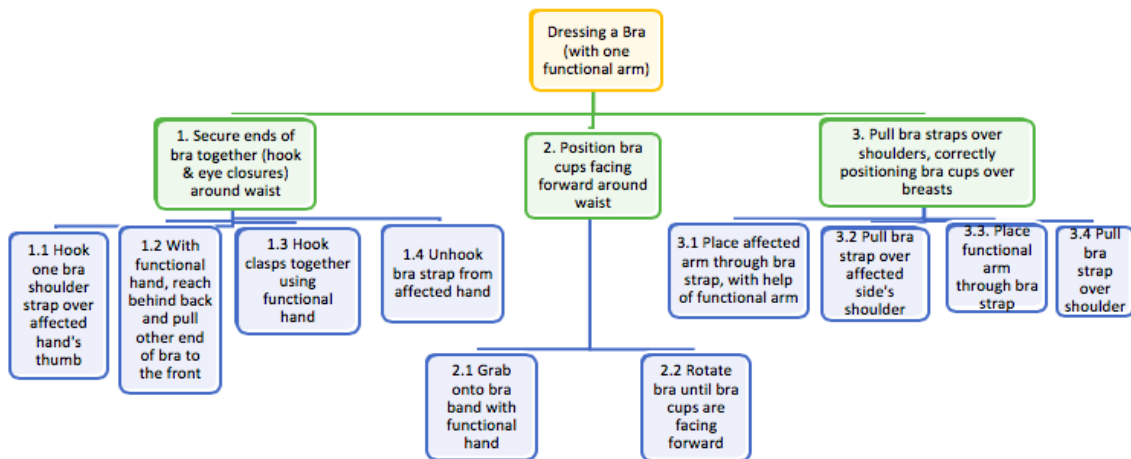


Figure 2

HTA: Dressing a Bra with One Functional Arm



Appendix B: Tabular Task Analysis

Task / Subtask	Duration	Physical Demand	Sensory/ Perceptual Demand	Cognitive Demand	Affective Demand	Environmental Demand

<p>0. Select bra to wear, place on lap of the wearer</p>	<p>~10 sec</p>	<p>-Having functional muscular capabilities to pick up a bra, and to orient the bra onto one's lap -Finger dexterity requirements -Triceps, Biceps Shoulder and forearm extensor/flexors to find and pick up a bra -Leg muscles necessary to walk, find and pick up a bra -Flexibility of trunk muscles to bend the torso and select a bra <i>-Finger and wrist flexion/extension</i> <i>-Shoulder abduction, adduction, and internal rotation</i> <i>-Elbow flexion/extension</i> -Grip strength to grab onto a bra</p>	<p>-Must be able to sense bra (visual or tactile) to identify one to wear -Must be able to feel the bra to pick it up and place in on the lap</p>	<p>-Requires cognitive capabilities to recognize what a bra is, and the steps required to put a bra on with one functional arm (put on one's lap) -Cognitive ability to choose a bra to wear</p>	<p>-Perhaps some frustration in not finding the correct bra the user wishes to wear -Or satisfaction in finding a specific bra the user is content with wearing</p>	<p>-Balance demands = user requires a straight (not uneven) floor surface to sit or stand on, to ensure the user can maintain their footing</p>
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<p>1.1 Hook one bra shoulder strap over affected hand's thumb</p>	<p>~2 - 5 sec</p>	<p>-Finger dexterity requirements -Triceps, Shoulder and forearm extensor use to secure the bra strap to affected hand's side -Flexibility of trunk muscles <i>-Shoulder abduction, adduction, and internal rotation</i> <i>-Elbow flexion/extension</i> <i>-Grip strength</i></p>	<p>-Must be able to sense bra strap (visual or tactile) to hook it onto the affected hand's thumb</p>	<p>-Requires cognitive capabilities to understand the adaptive sequence of putting on a bra, by hooking the strap onto the affected hand's thumb to begin the dressing sequence</p>	<p>-This task could lead to some minor frustration, due to affected arm/hand not cooperating</p>	<p>-Have enough space in the environment to comfortably hook bra strap onto the thumb -Balance demands = straight (not uneven) surface to sit or stand on -Place to sit; comfortable surface that is tidy</p>
<p>1.2 With functional hand, reach back behind and pull other end of bra to the front</p>	<p>~5 - 10 sec</p>	<p>Finger dexterity requirements -Arm flexors/extensors, shoulder and scapular rotators use to push the bra to other side of the body (to the front, from the back) -Flexibility of trunk muscles <i>-Shoulder abduction, adduction, and internal rotation</i> <i>-Elbow flexion/extension</i> <i>-Grip strength to grab onto end of bra, and pull to the front</i></p>	<p>-Proprioception ~ Must be able to recognize where the arm/upper extremities are in space, to ensure the arm is grabbing onto the bra in the right space -Tactile sensation ~ to identify the feeling of the other end of the bra, in order to pull it forward.</p>	<p>-Requires cognitive capabilities to understand the adaptive sequence of putting on a bra, to perform the next sequence by grabbing the other end of the bra behind the user, towards the front.</p>	<p>-Some frustration may occur in this subtask, if the user cannot feel or reach the bra strap behind them.</p>	<p>-Have enough space in the environment to be able to comfortably grab the bra strap behind the back of the user, to pull it towards the front of the body -Balance demands ~ a straight floor or surface to sit/stand on, so the user can maintain their balance and not fall over when grabbing the bra behind them.</p>

<p>1.3. Hook/Fasten the bra clasps using functional hand</p>	<p>~8 - 30 sec potentially longer depending on if the client is having difficulty</p>	<p>-Finger dexterity requirements -Triceps, Shoulder and forearm extensor use to attach the bra clasps together, to ensure security <i>-Finger and wrist flexion/extension</i> <i>-Shoulder abduction, adduction, and internal rotation</i> <i>-Elbow extension</i> <i>-Grip strength to hold bra clasps together</i></p>	<p>-Must be able to sense bra and bra hooks (visual or tactile) to correctly connect the bra hooks together -Must have proprioceptive knowledge of where the body is in space, to accurately fasten the bra clasps.</p>	<p>-Requires cognitive capabilities to recognize clasps, and understand how to hook the clasps together for the purpose of wearing a bra</p>	<p>-Potential for great Frustration; It can take longer if the client is having difficulty, and requires multiple attempts to tie the clasps together can become infuriating</p>	<p>-Have enough space in the environment to comfortably fasten the clasps (hooks and eyes) on the bra</p>
<p>1.4 Unhook bra strap from affected hand</p>	<p>~2 - 5 sec</p>	<p>Finger dexterity requirements -Triceps, Shoulder and forearm extensor muscles of unaffected hand used to push the bra strap off of the affected hand <i>-Finger and wrist flexion/extension</i> <i>-Shoulder abduction, adduction, and internal rotation</i> <i>-Elbow extension</i></p>	<p>-Must be able to sense bra and bra hooks (visual or tactile) to correctly connect the hooks together</p>	<p>-Requires cognitive capabilities to complete the dressing sequence, by unhooking the bra strap from the affected hand.</p>	<p>-This action should be relatively easy to complete, and therefore not lead to frustration or anger.</p>	<p>-Have enough space in the environment to comfortably remove the bra strap from the affected hand</p>

2. Rotate the bra so that the cups are facing forward	~ 5 - 15 sec	<ul style="list-style-type: none"> -Finger dexterity requirements -Triceps, Shoulder and forearm flexors/extensors use to push the bra to other side of the body -flexibility of trunk muscles -<i>Finger flexion, wrist extension</i> -<i>Shoulder abduction, adduction, and internal rotation</i> -<i>Elbow flexion/extension</i> -<i>Trunk rotation</i> 	-Must be able to sense bra (visual or tactile) to identify one to be able to place the bra in the correct position	-Requires cognitive capabilities to understand the adaptive sequence of putting on a bra, by rotating the cups to their end position.	-This action should be relatively easy to complete, and therefore not lead to frustration or anger.	<ul style="list-style-type: none"> -Have enough space in the env. to comfortably put the bra on -Sufficient area and behind the user, so they are able to shift/rotate the bra hooks posteriorly, and the bra cups to the anterior of the body.
3.1. Place functional arm through the adjacent strap for support	~2 - 5 sec	<ul style="list-style-type: none"> -Finger dexterity requirements -Biceps, Triceps, Shoulder and forearm flexors and extensors use to push the bra strap into the functional arm's strap hole -Flexibility of trunk muscles -<i>Finger flexion, wrist extension</i> -<i>Shoulder abduction, adduction, and internal rotation</i> -<i>Elbow flexion/extension</i> -<i>Trunk rotation</i> 	-Must be able to sense bra straps (visual, tactile, and proprioceptive) to place them into the appropriate arm	-Requires cognitive capabilities to recognize bra straps, and to understand the purpose or sequence of putting an arm through a bra strap hole to dress a bra	-This action should be relatively easy to complete, and therefore not lead to frustration or anger.	-Have enough space in the environment to comfortably place functional arm through bra shoulder strap

<p>3.2. Place non-functional arm through adjacent strap, with assistance of functional arm for support</p>	<p>~10 - 20 sec</p>	<p>-Finger dexterity requirements -Biceps, Triceps, Shoulder and forearm flexors and extensors use to push the bra strap into the non-functional arm hole (within the strap) -Flexibility of trunk muscles <i>-Finger flexion, wrist extension</i> <i>-Shoulder abduction, adduction, and internal rotation</i> <i>-Elbow flexion/extension</i> <i>-Trunk rotation</i></p>	<p>-Must be able to sense bra straps (visual, tactile or proprioceptive) to place them into the appropriate arm.</p>	<p>-Requires cognitive capabilities to recognize bra straps, and to understand the purpose or sequence of putting an arm through a bra strap hole to dress a bra</p>	<p>-Potential for great Frustration; It can take longer if the client is having difficulty, and requires multiple attempts to put their non-functional arm through the bra strap.</p>	<p>-Have enough space in the environment to comfortably put non-functional arm through the adjacent bra shoulder strap</p>
<p>3.4. Pull Bra straps over shoulder</p>	<p>~2 - 5 sec</p>	<p>-Finger dexterity requirements -Triceps, Shoulder and forearm flexors use to push the bra straps upward to their final position <i>-Finger flexion, wrist extension</i> <i>-Shoulder abduction, adduction, and internal rotation</i> <i>-Scapular elevation</i> <i>-Elbow flexion/extension</i></p>	<p>-Visual, tactile and proprioceptive sensory inputs to pull the bra straps over the respective shoulders</p>	<p>-Requires cognitive capabilities to recognize bra straps, and to understand the purpose or sequence of pulling both bra straps over the shoulder.</p>	<p>-Feelings of Relief and satisfaction once a braier is nearly complete</p>	<p>-Have enough space in the environment to comfortably pull the bra straps over the shoulders.</p>

4. Re-adjust accordingly	~5-15 sec	<ul style="list-style-type: none"> -Finger dexterity requirements -Triceps, Biceps Shoulder and forearm flexors/extensors use to re-adjust bra to final resting position -Flexibility of trunk muscles -<i>Finger and wrist flexion/extension</i> -<i>Shoulder abduction, adduction, and internal rotation</i> -<i>Elbow flexion/extension</i> -<i>Scapular elevation</i> -<i>Trunk rotation</i> -<i>Grip strength, to re-adjust bra</i> 	<ul style="list-style-type: none"> -Visual, tactile and proprioceptive sensory inputs needed to feel and see if the bra is comfortable, and in its final position (deciding whether more adjustments are required) 	<ul style="list-style-type: none"> -Requires cognition to understand what the final stage or position of the bra should look and feel like 	<ul style="list-style-type: none"> -Relief and satisfaction once a bra is on correctly 	<ul style="list-style-type: none"> -Have enough space in the environment to comfortably re-adjust the bra -Durability demand ~ the device needs to be able to be reset easily in the environment -Durability demand ~ the device needs to be able to be maintained; or easily cleanable to maintain infection control standards
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Appendix C: Subjective Analysis

Questionnaire for Subjective Analysis

Participant #

1. Anthropometric data
 - a. Weight
 - b. Height
 - c. Arm length
 - d. Bust
 - e. Waist
 - f. Hip

Multiple choices (Please select all that apply)

2. what type of bra do you wear ?
 - a. Push-up Bras
 - b. T-shirt Bras
 - c. Demi and Balconette Bras
 - d. Maternity Bra
 - e. Strapless Bra
 - f. Other please specify
3. How many hooks your bra have
 - a. 2
 - b. 4
 - c. 6
4. What characteristics of bra aid are important to you?
 - a. Lightweight
 - b. Easy to use
 - c. Price
 - d. Others to specify:
5. Do you have a preference for the way of using a bra dressing aid? If yes please note
 - a. Fasten in the front of the body
 - b. Fasten behind of the body

Short answer questions

6. What features of bras work/don't work for you?
7. Please provide some background about the diagnosis
8. What specifically makes dressing bra difficult?
9. Do you have any suggestions that you feel would improve the task or make it easier?
10. Do you perceive a psychological impact from not being able to dress a bra independently? If yes please specify...
11. Do you figure out a way of dressing bra independently? If yes can you describe what strategy you use, how?

Rating scale questions

12. Rate how satisfied you are with your ability to dress bra now

0 1 2 3 4 5 6 7 8 9 10

Not satisfied at all Very satisfied

13. Are you able to dress bra independently currently, if yes please answer

○ Rate the fatigue level with dressing a bra

0 1 2 3 4 5 6 7 8 9 10

No fatigue at all High fatigue

14. Please rate how important dressing a bra independently to you

0 1 2 3 4 5 6 7 8 9 10

Not important at all Very important

15. Rate how comfortable you are dressing a bra with the help of the partner or health care provider

0 1 2 3 4 5 6 7 8 9 10

Not comfortable at all Very comfortable

Customer Reviews on Amazon:

BraBuddy: <https://www.amazon.ca/Bra-Buddy-Fastening-Aid/dp/B01NBIWRA9>

BraAngel: https://www.amazon.ca/Buckingham-Angel-Dressing-Allows-Using/dp/B0056PPKVS/ref=sr_1_2?dchild=1&keywords=bra+angel&qid=1615674419&sr=8-2

Appendix D: Weighted-Decision Matrix

Averaged Weighted Decision Matrix

Weighted Decision Matrix- Averaged		Weight (%)	Silicone slap band	Tabs attached to wall	Belt with tabs	Magnet bra
Efficiency	Ease of fastening	20	1.5	1.15	1.1	1.7
	Ease of wrapping around waist	20	1.75	1.3	1.35	0.75
	Ease of reset	15	0.8625	1.0875	0.825	1.0125
Convenience	Cost	10	0.75	0.825	0.7	0.8
	Portability	5	0.3375	0.0875	0.325	0.4375
	Lightweight	5	0.375	0.4625	0.3625	0.3625
	Durability	5	0.3125	0.35	0.3375	0.3375
	Comfortable (material)	5	0.2625	0.375	0.325	0.375
	Compatible for different types/sizes of bras	15	1.2375	1.35	1.2	1.3125
TOTAL WEIGHTED:		100	7.3875	6.9875	6.525	7.0875