Development of Kitchen Models for Wheelchair Users
- Focused on the Development and Evaluation of a System Kitchen Model Which Reflects Conditions of Korea and Universal Design Concepts

Young-Jun KO*, Takashi KUDO**

*Yongin Songdam College Department of Industrial Design, 571-1 Maypungdong, Yongin 449-710 KOREA, yjko@ysc.ac.kr
** Kinki University Division of Systematic Design, 11-6 Kayanomori, Iizuka 820-8555JAPAN, Kudotaku@fuk.kindai.ac.jp

Abstract: Although many wheelchair users in Korea remodeled their kitchens to solve the inconvenience of using their kitchens, most of them are not satisfied with the results. In relation to this, some people complained about the difficulty in finding proper materials when remodeling kitchens and pointed out that some kitchen elements, remodeled using foreign materials, did not meet the conditions of Korea. Also some wheelchair users said that their family members even felt inconvenienced when using kitchens after remodeling them, while they felt the kitchens became a little more convenient. Considering this, a study has been carried out to present a kitchen model for wheelchair users that reflects the Korean situation and universal design concepts.

To carry out this study, first, literature on the dietary life of Koreans and the findings of former research on kitchens for wheelchair users were analyzed. Then based on this literature, design concepts reflecting conditions of kitchens, wheelchair users in Korea, and universal design criteria, a full size system kitchen prototype was developed. After that, we asked 12 wheelchair users and six non-disabled persons to evaluate its main elements, like the lowered counter and movable cabinets etc. in terms of universal design and the specific Korean situation. To assess the kitchen model from a universal design standpoint, we made an evaluation standard transforming the four universal design principles. As a result, the lowered counter, the pull out cabinets and the movable cabinet were evaluated high from a universal design perspective. The appearance of kitchen model didn’t appear to be different from the kitchen that general people use and appealed to all participants. The movable cabinet under the cook top was assessed as making efficient use of small kitchen spaces in Korea. However, it was determined that the halogen cook top needed more research in respect to overflowing onto its surface - that is, most Korean food is hot and contains a lot of liquid.

Key words: Kitchen Design, Wheelchair Users, Dietary Life in Korea, Universal Design

1. Introduction

Many wheelchair users remodeled their kitchens so that they can remove the difficulties when using them, but most of them are not satisfied with the results of the remodeling. There are various reasons why the results are not satisfactory. For example, the shortage of people or companies that specialize in remodeling for wheelchair users is pointed out as a major reason. In addition, the lack of proper materials that wheelchair users in Korea can refer to when they try to remodel kitchens is a problem. For these reasons, they frequently depend on foreign literature related to kitchen design for disabled people, including wheelchair users. However, these materials were found to have some limitations when applied to the Korean situation, even though they stemmed from systematic studies
by various specialists. This is because Koreans are leading a different dietary life, and their use of kitchens is different from those of western countries. Besides, some wheelchair users are not satisfied with the appearance of the remodeled kitchens they have referred to in foreign literature.

In the study on remodeled kitchens [1], some wheelchair users said that since the knee space under the sink made their kitchens look different from general kitchens, they might have to re-convert remodeled ones into their original state to prevent the resale value of their houses from decreasing when selling them. There are also some people who later attached doors to the knee space to cover it, as they didn’t like the appearance of the kitchen with the knee space opened. Some people in wheelchairs also pointed out that making knee spaces as well as lowering counters worsens the shortage of storage space.

Another problem mentioned by some wheelchair users was that kitchens remodeled for wheelchair users caused inconvenience to their family members. According to the study, some considerably lowered kitchen counters for wheelchair users to do kitchen work while sitting on kitchen floors revealed that they gave much inconvenience to their family members in using kitchens. Reflecting on the unique Korean life style, this way of remodeling also lead to the reduction of storage space. Some wheelchair users made an additional cabinet to supplement the reduction of storage space. Considering the above problems, this study aims at developing and evaluating a kitchen model for wheelchair users which reflects universal design concepts and the specific Korean situation. Concrete objectives of this study are as follows:

1. To develop a kitchen model based on design concepts which have been formulated by combining former studies and universal design criteria.
2. To evaluate the appropriateness of the prototype by using wheelchair users and non-disabled persons.
3. To present design guidelines needed for making kitchens for wheelchair users in Korea.

2. Methods

2.1. Design Development

First, analyses of the specific dietary life of Koreans and the characteristics of kitchens and wheelchair users in Korea, which resulted from former studies, were carried out. Combining the result of the analyses and universal design standards, design concepts for a system kitchen model were created. Based on the design concepts, two full-size, I type system kitchen models with similar design, were developed and installed at a Korean rehabilitation center and a hospital respectively.

2.2. Evaluation

The evaluation of the kitchen prototype was conducted at one of its installation sites to assess whether the main features of it, such as the lowered counter was useful for people to do kitchen work or not. Of the 18 people who evaluated the kitchen model, 12 were wheelchair users (six female, six male) and six were non-disabled people (three female, three male). The ages of the participants ranged from 30 to 50. The evaluation consisted of three parts: evaluation of universal design criteria, evaluation of aesthetics and cultural perspectives and a subjective evaluation of the effectiveness of major kitchen appliances. As a result, the kitchen model was evaluated to meet the design concepts. Some kitchen design guidelines were also presented.

2.3. Limitations of Study

In this study, I type kitchen model was made in consideration of space limitation and a survey based on it being the most common kitchen type in Korea. In general, an evaluation of a newly created prototype requires
enough time so that research subjects can thoroughly apprehend its usability. But, in this study, the model was assessed just after its installation. In addition, the fact that the evaluation was carried out on the model installed at rehabilitation center, not one in a kitchen of a general household could also be a limitation of the study.

3. Kitchen Design Considerations

3.1. Dietary Life of Koreans

Although the dietary life of Koreans is becoming westernized, as their life styles change, most Korean food is still different from that of other countries. Like different food, different containers and appliances are used to make and serve food. In general, Korean food is spicy, hot, and contains a lot of liquid. Bean Paste Soup, and Spicy Beef Soup are examples of two popular hot Korean soups. To serve such food, deep, thick bowls are generally used instead of thin plates. Therefore, spoons are always used to eat hot and juicy food (Fig. 1).

To boil hot soup, various types of pots are used; hence spilled soup from the pots can be dangerous and cause burning and cleaning problems. Also, removing food waste with a lot of water can be a problem. To handle the water coming out of the waste, many Korean households have a waste container with an additional part to collect the water (Fig. 2).

![Fig. 1. Korean food](image1.jpg)  ![Fig. 2. Food waste collecting container](image2.jpg)

3.2 Findings of Former Studies

According to earlier studies, it became clear that kitchens for wheelchair users in Korea have many problems. In relation to the problems, the following major findings need to be considered when designing kitchens for wheelchair users in Korea:

- One study [2] shows that most wheelchair users in Korea appeared to use I type kitchen and do kitchen work in a small space less than 5 pyong (16.5m²: Pyong is a Korean measuring unit.). In respect to kitchen elements, wheelchair users felt uncomfortable especially when using upper cabinets, sinks, and range hoods.

- In another study, it appears that some wheelchair users in Korea hesitated to make knee space or leave it open because of appearance and the reduction of storage space, although they recognized its functional advantages [3]. For this reason, there were some wheelchair users who later attached doors to the knee space in order to close the opening.

- Wheelchair users frequently move things by putting them on their laps, but, in this study, they were not able to do this when they had to carry hot food or wet food waste. So they completed the task by holding stuff with one hand while rolling their wheelchair wheels. Since wheelchair users had to change their hands frequently while
holding something, it was very difficult. Therefore, it took more time and required a wider passage way. Since most Korean meals comprise hot and juicy food, this problem should be given much more weight.

4. Design Development

4.1. Design Concepts

Combining major findings of former studies and four universal design principles [4], design concepts for a system kitchen model were formulated. As mentioned in “Universal Design Exemplars” [5] published by the Universal Design Center, universal design principles are not intended to constitute all design criteria for a good design, but for a universally usable design. Therefore, to attain good design concepts, other important factors such as aesthetics, cultural considerations, and cost were supplemented to the universal design criteria.

1) Adaptable design
   • The design should accommodate not only wheelchair users, but also their family members.
   • The height controls of kitchen appliances should be easy.

2) Safety-oriented design
   • The design should provide fail-safe features and isolate or shield hazardous elements.

3) Supportive design
   • The design should be used efficiently and comfortably with minimum efforts.
   • It should be designed for wheelchair users to store things at ease.

4) Accessible design
   • The kitchen model should be created for people in wheelchairs to access it easily.
   • Kitchen cabinets and counters should be placed within the reach of wheelchair users.

5) Aesthetics
   • The appearance of kitchen model should not be different from the kitchens which general people use.
   • The design should be harmonized with the interior where the kitchen model is located.

6) Cultural / regional considerations
   • The design should reflect the specific dietary life of Korean people.
   • It should maximize the small space of most kitchens in Korea.
   • The design should accommodate the size of Korean people.

7) Cost
   • The kitchen model should be produced at an affordable price.

4.2. Kitchen Model

Based on the design concepts, idea sketches, renderings, and study models were created and system kitchen designs took concrete shapes. Of the various design ideas selected from the renderings and study model presentation, one idea was decided as the final design. On the basis of the final design, two prototypes were produced and installed at both NRC (The National Rehabilitation Center) in Seoul and CRH (The Choongang Rehabilitation Hospital) in Inchon. Considering the conditions of each installation place, slightly different configurations of the prototypes were made. In addition, in order to compare the usability of cook tops, a slim gas range and a halogen cook top were placed at NRC and CRH respectively.
The following are main features of the kitchen model (Fig. 3):

(1) In the model, a lift rack (Fig. 4) was attached to the wall cabinet. This fitting allows the metal storage basket in the wall cabinet to be lowered to a more easily accessible height. There is no loss of cupboard space when the unit is folded away. A long bar handle is attached to the bottom of the basket.

(2) The counter height (Fig. 5) was set 78cm, which is 7cm lower than the average counter height in Korea, to accommodate not only wheelchair users but also people like short women and children as well as general people. If necessary, people can raise the height to 85cm by replacing the kick plate which is 10cm to 17cm in height.

(3) Movable cabinets below the counter are designed for multi-purpose use. The space occupied by the cabinets
becomes knee space by rolling them out for wheelchair access. The cabinets are to provide storage spaces and a convenient and safe method for transporting things like hot pots to the kitchen table (Fig. 6).

(4) The pull out table directly below the microwave space in the tall cabinet allows hot items to be stayed and facilitates the access of seated users including people in wheelchairs.

(5) The pull out cabinet on full-extension guides (Fig. 7) was attached to the basic cabinet, so wheelchair users can take out items without bending.

(6) A halogen cook top, recommended by researchers including Cynthia Leibrock [6] as being good for reducing the danger of burns and fire, was installed on the top of the counter. The smooth surface cooker allows pots or pans to be moved easily without lifting them and enables the surface to be cleaned easier than other cookers.

(7) The slim, 45mm gas range, installed in the model at NRC, has the advantage of providing enough room to make knee space below the cooker.

(8) The pull out table under the cook top (Fig. 8) provides a landing pad for hot food that has been moved from the cook top.

(9) The remote control (Fig. 9) is used for wheelchair users with limited reach to operate the range hood.

(10) A hand held pullout spray faucet, near the cooking surface allows wheelchair users to fill pots without maneuvering their wheelchairs.

5. Evaluation

5.1. Evaluation of Universal Design Criteria

For the evaluation, the four universal design principles, formulated by Ronald Mace, were basically used.
Since it is difficult to apply the principles for evaluating the kitchen model as it is, some criteria were transformed to fit the purpose. The results of 18 respondents’ answers are shown in Table 1. The number in each square represents the appropriateness of the design from universal design points of view. Evaluation scale consists of –2(fully agree), -1(agree), 0(neutral), 1(disagree) and 2(fully disagree).

As a result, on the whole, the model was assessed positively (0.67). Of the six main features of the kitchen model, the lowered counter (sink) was evaluated the highest (0.95) from wheelchair users who participated in the evaluation, followed by the pull-out cabinet (0.75), the movable cabinet under the cook top (0.69), pull-out tables (0.66) and the halogen cook top (0.57). The lift rack, installed on the wall cabinet of the model, was assessed relatively low (0.38).

While rating the lowered counter high in 1A(1.33), 1B(1.25), 2A(1.41), 3A(1.16) and 3B(1.25), they evaluated it low (0.16) in the criterion of convenience for the wheelchair users’ family members. For the pull-out cabinet, the evaluation results in 1A(1.25), 1B(1.25) and 2A(1.00) were high, but those in 2B(0.33), 3A(0.25) and 4A(0.33) were relatively low. The movable cabinet under the cook top was high in 1B(1.08) and 2A(1.08), but was relatively low in 2B(0.33) and 4B(0.25). The pull out tables received high assessments in 1A(1.25), 1B(1.08) and 2A (1.00). The halogen cook top was evaluated high in 3B(1.16), but it was negatively assessed in 4A(-0.25). Such a negative response in 4A was attributed to an assumption that the cook top would not be safe if boiled soup overflowed on it. The lift rack was rated high in 1B(1.08), but not in 4A (-0.50) and 4B(-0.41).

Table 1. The evaluation results by universal design criteria. (N=18)

<table>
<thead>
<tr>
<th></th>
<th>Lift rack</th>
<th>Lowered counter (sink)</th>
<th>Movable cabinet (under the cook top)</th>
<th>Pull out cabinet</th>
<th>Halogen cook top</th>
<th>Pull out tables</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)Supportive</td>
<td>1A. The design can be used with low physical effort.</td>
<td>0.58</td>
<td>1.33 (0.66)</td>
<td>0.91</td>
<td>1.25</td>
<td>0.75</td>
</tr>
<tr>
<td>design</td>
<td>1B. The design provides a necessary aid to function.</td>
<td>1.08</td>
<td>1.25 (0.50)</td>
<td>1.08</td>
<td>1.25</td>
<td>0.25</td>
</tr>
<tr>
<td>(2)Adaptable</td>
<td>2A. The design adapts to meet the needs of the wheelchair user.</td>
<td>0.91</td>
<td>1.41</td>
<td>1.08</td>
<td>1.00</td>
<td>0.91</td>
</tr>
<tr>
<td>design</td>
<td>2B. The design is convenient for the family members of the wheelchair user.</td>
<td>0.50</td>
<td>0.16 (0.33)</td>
<td>0.33</td>
<td>0.33</td>
<td>0.33</td>
</tr>
<tr>
<td>(3)Accessible</td>
<td>3A. The design is easy to approach</td>
<td>0.16</td>
<td>1.16 (1.00)</td>
<td>0.58</td>
<td>0.25</td>
<td>0.83</td>
</tr>
<tr>
<td>design</td>
<td>3B. The user’s hands easy to reach appliances.</td>
<td>0.75</td>
<td>1.25 (0.66)</td>
<td>0.75</td>
<td>0.91</td>
<td>1.16</td>
</tr>
<tr>
<td>(4)Safety-</td>
<td>4A. The design provides fail-safe features.</td>
<td>-0.50</td>
<td>0.25 (0.33)</td>
<td>0.50</td>
<td>0.33</td>
<td>-0.25</td>
</tr>
<tr>
<td>oriented design</td>
<td>4B. The design arranges elements to minimize hazards.</td>
<td>-0.41</td>
<td>0.66 (0.50)</td>
<td>0.25</td>
<td>0.66</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>0.38</td>
<td>0.95 (0.57)</td>
<td>0.69</td>
<td>0.75</td>
<td>0.57</td>
</tr>
</tbody>
</table>

*The numbers in parentheses represent the non-disabled participants’ assessment.
Non-disabled people evaluated only the lowered counter, which seemed to be the one of the most critical elements in kitchen design from a universal design point of view. The evaluation by the non-disabled participants was positive overall (0.57), but the figures were lower than those assessed by wheelchair users.

5.2. Evaluation of Aesthetics and Cultural Perspectives

In respect to aesthetics and cultural aspects, participants made a general evaluation rather than an individual one on each item such as lift rack because it seemed to be difficult for them to appreciate each item on these aspects. The kitchen model was favorably assessed in respect to the aesthetics perspective from the wheelchair users. Regarding the criterion that “the appearance of the kitchen is not different from that of the kitchens which general people use and it is in harmony with the interior where it is located”, the participants rated high (1.25).

Regarding the criteria related to regional or cultural conditions, participants gave somewhat different responses. While the assessment on the question that “the design accommodates Korean people and the small space of kitchens in Korea” was relatively high (0.83), the evaluation on the criterion that “the design reflects the specific dietary life of Korean people” was close to neutral (0.33).

5.3. The Effectiveness of Major Kitchen Elements

Along with the objective evaluations both in universal design and cultural aspects, subjective questions asking the usefulness on key elements such as counter height, knee spaces, movable cabinets, pull out tables, and lift rack etc., were given. As a result, the kitchen model was verified to be useful in many ways, and some problems were also pointed out. The following are answers to the questions:

(1) In respect to the counter height (78cm) being lowered by around 7cm more than the conventional one, all but one wheelchair user (92%) was satisfied with it. He was of the opinion that raising the counter by 2cm to 80cm from the kitchen floor would be better because his knees toughed underneath the sink bowl. This problem would be alleviated if a sink bowl of 15 cm deep were installed on the kitchen counter. Unlike the original design, a 17cm deep sink bowl on the counter was installed because we could not find one. Of the non-disabled participants, one male answered that the lowered counter was a little bit low for him to use. In respect to the knee space under the sink, all wheelchair users except one answered that it was convenient, although their knees bumped slightly into the pipes under the sink. As for the knee space under the cook top, seven wheelchair users (58%) said it was convenient for them to use, but five (42%) replied that the knee space was a little narrow for wheelchair access, and their knees touched slightly underneath the pull-out table.

(2) In respect to the movable cabinet, which can be placed into the knee space under the cooker, ten wheelchair users (83%) answered ‘good’ because the rollout cabinet can be used for various purposes including an additional work surface. In contrast to this, on the movable cabinet under the sink, eight wheelchair users (67%) gave negative opinions because the shallow cabinet was unstable and reduced the effectiveness for storage. As shown in Fig. 6, its depth was originally 60cm but was reduced to 35cm to accommodate the water pipe and heat pipe located under the sink. Given this situation, attaching retractable doors or fold-back doors to the knee space seems to be better than placing the movable cabinet in the knee space.

(3) As for the pull-out table under the cook top, eight wheelchair users (67%) recognized its need, but three (25%) pointed out that placing it on the right or left side from the present location would be better in terms of usability, and one person was of the opinion that placing a drawer rather than the pull-out table
would be more convenient. While ten wheelchair users (83%) liked the pull-out tables under the microwave section or rice cooker section in the tall cabinet, two (17%) pointed out that the height of the pull-out table under the rice cooker space was too low. All wheelchair users favored the idea of making the rice cooker cabinet movable by attaching casters, as they could easily transfer the cooker and rice containers to a kitchen table. It seems that making the cabinet movable, like the movable cabinet under the cook top, has an additional advantage of providing a knee space when using a microwave.

(4) Six wheelchair users (50%) answered that the lift rack was convenient, whereas three (25%) expressed difficulty in reaching it. The remaining three wheelchair users raised concerns about the lift rack. That is, they suggested it needed to stop for a period of time while they are using it. They also had concerns about the clatter of plates while it was being pulled down. According to Mary Jo Peterson [7], the average person who remains seated to maneuver in the kitchen has a forward reach range of 38cm-122cm off the floor. If there is an obstruction like a counter, the upper limit drops. Considering this, it should be designed lowering the present location of the lift rack handle to about 120cm off the floor, or use a connecting tool for some wheelchair users with short reach.

(5) In respect to the halogen cook top (Fig. 10), eight wheelchair users (67%) answered positively because it was slim and looked easy to clean, but four people (33%) pointed out problems such as danger of overflowing hot soup and its inappropriateness when making a large amount of soup. While halogen cook tops reduce burns and fire and offer more stability for pots and pans, it appeared that it has some limitations for kitchens in Korea. Considering most Korean food contains a lot of liquid, the danger of overflowing hot soup should be seriously addressed. As for the gas range, which was assessed by examining the picture (Fig. 11) taken at NRC, two wheelchair users (17%) pointed out that it would be better for transferring containers if its grills were continuously extended without being cut off.

(6) While all participants were satisfied with the remote control for the range hood, one wheelchair user suggested the idea of controlling other electronic devices such as a radio, or television with the same remote control. In respect to the range hood, one wheelchair user said that she preferred a compact and slim range hood with only its control part protruding out of the wall cabinet. That was because the massive metal range hood, which protruded out of the cabinet, could overawe people in wheelchairs.

6. Conclusions
The evaluation of the kitchen model showed that it has various features of universal design and cultural
aspects, as well as some problems need to be solved. The following are major findings from this study, which can be used as kitchen design guidelines:

1. In order to move rice, making the rice cooker storage in the tall cabinet movable, like the movable cabinet under the cook top should be considered.

2. Using the remote control for the range hood was identified as being very useful for wheelchair users.

3. Given the situation that in many kitchens in Korea, like the installation site for the kitchen model, space under their kitchen sinks is mingled with things such as plumbing pipes and heating pipes. Therefore, placing a movable cabinet under the sink appeared undesirable. Instead of this, installing either retractable doors, retracted when a wheelchair user use the sink, or fold-back doors seems to be better than placing the movable cabinet under the sink.

4. While placing a pull-out table somewhere under the cook top appeared to be useful, more study should be done to find out its best location to maximize its usability. As suggested in the evaluation process, placing it to the right or left side of the present location should be considered.

5. While the lift rack was identified to be convenient for some wheelchair users, it raised several problems need to be solved. It was pointed out that the lift rack should be stopped for a certain period of time so that users can put in or take out plates after it is pulled down. Also, some people pointed out that the clatter of plates and dishes while pulling the lift rack up and down was harsh to their ears.

6. The smooth surface halogen cook top has the disadvantage of having less capacity to catch spilled liquids, which may increase the risk of burns for someone sitting near it. Considering a lot of Korean food is juicy and hot, this problem should be solved.

7. The lowered counter was identified as being useful for most wheelchair users and people with a short stature. However, for some tall people, it appeared not to be convenient. For this reason, the study on counters that adjust in height electrically or mechanically for a variety of users should also be pursued.

References