

Application of Universal Design in the Design of Apartment Kitchens

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Abstract

The purpose of this study is to suggest designs for apartment kitchens without major redesign for the elderly or the disabled, who are a fast growing population in Korea. According to the concept of universal design and the need to support various users as much as possible, five criteria for analysis were developed based on research on the mobility of wheelchair users: clear floor space, work flow, universal reach range, area for later use, and safety. Using the criteria developed, the accessibility and usability of five kitchen subtypes were investigated through the analysis of architectural documents. The result shows that kitchen layouts in Korean apartments are typically difficult to navigate for wheelchair users. Modification of the locations of the refrigerator, sink, and range was mainly required for appropriate clear floor space, work triangle, and countertops. Moreover, alternatives to five unit types were suggested without the need to increase the current kitchen size. For application of universal design to kitchen design, considerations for not only the size, the shape of the kitchen and its appliances but also for clear floor space, work triangle, countertop, reach range, and knee clearance formed by the location of each appliance are required.

Keywords: universal design; apartment kitchen; wheelchair user; spatial dimension; fixture layout

1. Introduction

Recently, the elderly population in Korea has been growing rapidly and the number of disabled people has also continued to increase. House design supporting their reduced motion and sensory capabilities caused by aging and disability has become an important issue.

In terms of housing welfare, 'aging in place' (enabling the elderly to continue living in the community they are familiar with) is more helpful to enjoying a better quality of life and maintaining better general health than leaving the family or community home and entering retirement living options or nursing homes (Balandin and Chapman, 2001). In addition, the elderly themselves showed strong attachment to their home and community where they had lived and they were unwilling to move out of the community (Choi, 2000). Therefore, architectural design measures for 'aging in place' are required.

The kitchen is one of the most frequently used places in the home. The use of the kitchen is essential for preparing food, carrying out household activities, and maintaining family contact in the home. If

individuals have problems accessing storage cabinets, using appliances, and maneuvering inside the kitchen, they become dependent on others for nutritional assistance. Therefore, independent use of the kitchen needs to be a basic condition for independent living in modern society (Mullick and Levin, 2001). In Korean residential buildings, research confirms that the kitchen is where the greatest number of accidents occur for the elderly (Moon and Kim, 2004). It is also a space that most often requires alterations to be made in order to meet the needs of the elderly and wheelchair users (Kim *et al.*, 2006; Kwon *et al.*, 2001). Therefore, kitchen designs that are usable by people with various capabilities are required.

In Korea, the government has already implemented several laws to support safe and convenient residential lifestyles for the elderly and the disabled. Moreover, for the elderly and disabled, guidelines for residential remodeling, facility standards for designing public rental housing, and an industrial standard for designing dwellings were also developed. These guidelines and standards consist of general principles and guides for residential design and remodeling, but they need to be complemented and clarified in their detailed descriptions in terms of the usability of the kitchen, which might be affected by the shape and layout, work triangle composition, countertop distribution, and so on.

It is evident that the application of these guidelines developed in Korea could contribute to safety

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(Received October 6, 2015 ; accepted July 11, 2016)
DOI <http://doi.org/10.3130/jaabe.15.403>

and convenience for the elderly and the disabled. Nevertheless, houses designed for the disabled and differentiated from common housing are viewed in a negative light by both groups with or without disability (An, 1998). In addition, in some cases, even if alteration is required in order to meet the needs of occupants, it could be difficult or impossible to modify residential spaces for reasons of finance, architectural structure, plumbing equipment, etc. Therefore, the concept of universal design, which refers to designing spaces to be usable by the widest range of people without adaptation or specialized design, needs to be applied to common housing design.

Thus, the aim of this study is to focus on the spatial dimension and fixture layout to deduce a method for the application of universal design to kitchen designs in apartments, which represents the main form of residential housing in Korea¹.

2. Methods

2.1 Selecting the Representative Group of Users

It could be said that universal design is the effort needed to reduce the gap between a person's abilities and the demands of their environment. For a design usable by all people to the greatest extent possible, the user group with the most limitations would be selected as the representative users. Motion capability, as the most important functional ability, should be considered in designing the spatial dimensions and fixture layout of the kitchen. Moreover, wheelchair users might be more vulnerable to the size, shape, and layout of the space than other people. Therefore, in this study, wheelchair users with no upper-body mobility or dexterity impairment were selected as the representative users².

2.2 Developing Criteria of Universal Design in the Kitchen

To develop the criteria of universal design in the kitchen, several universal design guidelines were analyzed such as: Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines, Access Board, U.S., 2004; Fair Housing Act Design Manual, HUD, U.S., 1998; Universal Kitchen & Bathroom Planning, Peterson, 1998; Manual for Residential Remodeling for Elderly Households, Ministry of Land, Infrastructure and Transport of Korea, 2007; Principles and Recommendations for

Designing Dimensions of Dwellings in Consideration of the Elderly, Korean Standards Association, 2006.

From the analysis of these guidelines, design elements concerning the spatial dimensions and fixture layouts were categorized into five groups: (1) clear floor space, (2) work flow, (3) universal reach range, (4) area for later use, and (5) safety³. In addition, criteria for the design elements for each group were developed based on the analysis of existing literature and guidelines⁴.

2.3 Selecting the Types of Dwelling Units

To categorize the types of dwelling units in apartments, data on 320 units of 59-114m² built in Seoul after 2000 were collected from 'Apartment Sourcebook (Sejin, 2006)'. According to the unit size, the units were categorized into 4 groups: 59, 84, 99, and 114m². In addition, in each unit size group, the dwelling units were categorized into several subtypes based on the spatial composition. As a result, five subtypes considered representative of each group were selected for investigation: type A and type B (45.7% and 36.2% of the 59m² group, respectively), type C (58.9% of the 84m² group), type D (66.7% of the 99m² group), and type E (77.5% of the 114m² group) (Fig.1.).

2.4 Analysis of Architectural Documents

Using the criteria developed, the accessibility and usability of the five kitchen subtypes were investigated through analysis of architectural documents. To analyze the spatial layout of the kitchen, 93 construction documents were examined (14 for type A, 19 for type B, 15 for type C, 29 for type D, and 16 for type E). In addition, eleven documents on kitchen wall elevations were examined to analyze the kitchen cabinet dimensions. As a result, the constraint factors of each unit type were summarized and in terms of universal design, applicable alternatives for each of the five unit types were suggested.

3. Criteria for Universal Design in the Kitchen

3.1 Clear Floor Space

(1) Clear floor space

Clear floor space refers to the minimum floor space needed for users to access and use kitchen appliances and fixtures. Table 1. shows the requirements of clear floor space and width of routes for wheelchair users. Clear floor space for either parallel or forward approach should be provided at each kitchen fixture



Fig.1. Unit Types Selected for Investigation

or appliance, e.g. sink, range, and refrigerator. In addition, considering both left and right handed users, the centerline of the clear floor space must be aligned with the centerline of the fixture or appliance.

(2) Parallel or forward approach

For some wheelchair users, a parallel approach to the sink or range is considered a barrier because it requires them to use fixtures in an uncomfortable position and can contribute to conditions such as scoliosis. Moreover, a forward approach to a fixture is difficult and unsafe for wheelchair users if knee clearance is not provided under the fixture. Thus, in the case of forward approach to a fixture, knee clearance should be provided under the fixture.

However, some wheelchair users are unwilling to use knee clearance because it requires removing the base cabinet of the fixture, thus reducing the storage space available in a small kitchen, and it appears to be a feature designed especially for the disabled.

Therefore, with consideration to providing as much space for the base cabinet as possible, clear floor space for parallel approach should be provided at the sink and range. In addition, under the sink, which is the most frequently used appliance in the kitchen, a removable base cabinet should be installed that can provide knee clearance for forward approach quickly and easily by removing the cabinet or pushing back the door into the cabinet.

3.2 Work Flow

Work flow refers to efficient fixture layout for preparing food and carrying out household activities in the aspect of work process, relationships between each work center, and length of countertops. A work triangle is the shortest walking distance between the refrigerator, sink, and range, measured from the center front of each appliance.

In Korea, the sink is the most frequently used appliance in the kitchen (Ko, 2003). And in preparing food, Korean users commonly use kitchen appliances

Table 1. Clear Floor Space for Wheelchair Users

Clear space	Requirements
Clear floor space	700mm x 1,200mm
Width of routes (including T-shape turn)	>=900mm

Table 2. Work Triangle and Countertop

Design element	Requirements
Work triangle (refrigerator-sink-range)	1,200-2,700mm (each leg of triangle) 3,600-6,600mm (total of the three legs)
Length of countertop	Refrigerator >=380mm (no more than 1,200mm across from the refrigerator)
	Sink >=610mm (on one side) >=460mm (on the other side)
	Preparation >=900mm (immediately adjacent to center sink)
	Range >=230mm (on one side) or >=80mm (at an end wall with flame-retardant material) >=380mm (on the other side)

in order of 'Refrigerator and its countertop - Sink and its countertop - Preparation center - Range and its countertop' (Yoon, and *et al.*, 1984).

Therefore, the sink should be located between the range and the refrigerator. Moreover, countertops for these appliances and the preparation center should be provided adjacent to each appliance. Table 2. shows the requirements for the work triangle and countertops. If two countertops are adjacent to one another, the minimum counter frontage requirement for the two adjoining spaces would be replaced by the longer of the two required counter lengths.

3.3 Universal Reach Range

The universal reach range refers to the height and depth of the storage cabinets and countertops usable by people with various capabilities including wheelchair users, seated users, and standing users with or without impaired mobility (Table 3., Fig.2.).

Wall cabinets are usually installed above the vertical universal reach range suggested in this study. Thus, it is difficult or impossible for wheelchair users to use the wall cabinets and it can also be difficult to install additional storage cabinets within the universal reach range due to the kitchen size. In this study, providing spaces for the installation of an additional pull-down shelf enables hard-to-reach items to be accessible while pulling out from the wall cabinet was suggested as a requirement of the area for later use. Therefore, the bottom of the wall cabinet should be within the universal reach range so that wheelchair users can pull down the shelf inside the cabinet.

Countertops should be at the same height as the sink and range so that a person with limited strength, grip, or balance can slide items onto the adjacent counter without lifting or lowering the items.

3.4 Area for Later Use

Area for later use refers to spaces provided for later installation of additional appliances in the same kitchen system in order to meet the needs of potential residents.

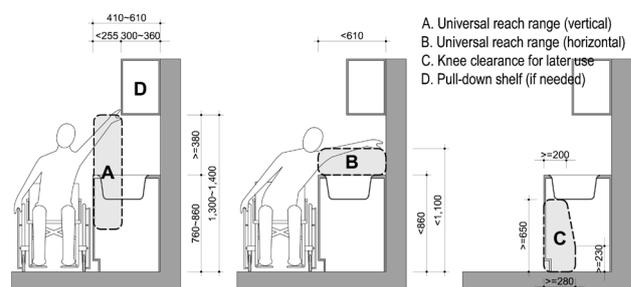


Fig.2. Universal Reach Range and Knee Clearance

Table 3. Universal Reach Range

Design element	Requirements
Universal reach range (vertical)	380-1,400mm
Universal reach range (horizontal)	<610mm
Height of countertop	760-860mm
Depth of countertop	410-610mm
Clearance between work surface and wall cabinet	>=380mm
Obstruction by projected base cabinet	<255mm

(1) Removable base cabinet

The removable base cabinet should be installed under the sink so that it can be selectively used for storage or knee clearance according to the occupants' needs. Considering not only the front approach but also the T-shape turn of wheelchair users, a 900mm wide cabinet should be installed and its centerline should be aligned with the centerline of the sink. C in Fig.2. shows the requirement for knee clearance. The knee clearance should be a minimum of 280mm deep at 230mm above the floor, and 200mm deep minimum at 650 mm above the floor.

(2) Pull-down shelf

A pull-down shelf, which could be additionally installed inside the wall cabinet to meet the users' later needs, should have a handle aligned with the centerline of the clear floor space for parallel approach by wheelchair users.

(3) Dish washer

Usually, a dishwasher is not installed due to the lack of sufficient base cabinets in small kitchens. However, a space for the installation of a dishwasher should be provided to meet the users' later needs. The edge of the dishwasher should be within 910mm of the edge of the sink and the appliance door should not intrude into the clear floor space for wheelchair users.

3.5 Safety

To prevent accidents such as fire, burning, and gas leaks, the range should not be placed below an operable window unless the window is 80mm or more behind the appliance and more than 610mm above it.

Fig.3. summarizes the suggested criteria for universal design and shows the relationships among them.

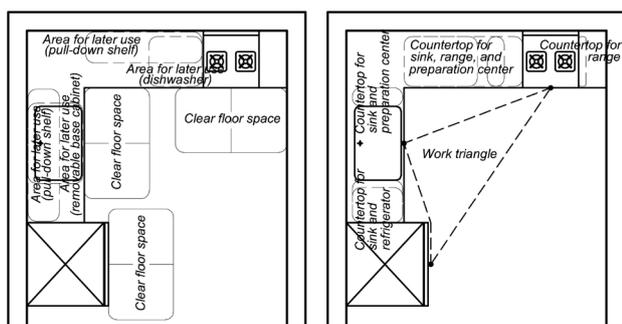


Fig.3. Criteria of Universal Design in the Kitchen

4. Results of Analysis of Architectural Documents

4.1 Clear Floor Space

The results of analysis of the clear floor space at the sink, range, and refrigerator is shown in Table 5. In types A and C, the ratio of problematic cases where a clear floor space for the sink was not provided was higher than in other types. This was mainly because the sink was installed in the corner of the L-shaped kitchen. In addition, for the refrigerator, no problematic case was presented, except a few cases in type B where the refrigerator was placed on the balcony. For the

range, the ratio of problematic cases was high in all unit types, which was mainly because the range was often installed immediately adjacent to the wall.

The percentage of cases where one or more problems with clear floor space were found and difficulty in using appliances was expected, was more than 50% in all unit types.

4.2 Work Flow

(1) Work triangle

Problems in which the sink was not located between the range and refrigerator within the work triangle occurred mostly in type B, where the refrigerator was placed on the balcony in most cases. This also contributed to the high percentage of problems of a long distance between the refrigerator and sink and a short distance between the refrigerator and range.

Problems of insufficient distance between the sink and range were found in all unit types. Especially, type A, where the L-shaped countertop was installed in a small kitchen, had a very high percentage of 86.4%. For the same reason, the ratio of problematic cases of short distance between the sink and refrigerator was high in type A. In addition, type E, where the kitchen is larger than that in other unit types and both ends of the work triangle were located far from each other, had a high ratio of problematic cases with long distances between the refrigerator and range.

The percentage of cases where one or more problems with the work triangle were found was more than 68.8% in all unit types.

(2) Countertop

In most cases for all unit types, the lengths of the countertops for the sink, range, and refrigerator were insufficient, except the countertops for the range, which should be more than 380mm in length and could be replaced by an adjacent longer counter. In types A and B, the total length of countertops was insufficient. The mean length of counters that needed to be additionally provided was 203.9mm and 265.0mm for types A and B, respectively. In types C, D, and E, the distribution of the countertop was inappropriate due to the location of the sink and/or range, although the total length of counters was sufficient.

The percentage of cases where one or more problems with the countertop were found and difficulty in using the kitchen was expected was more than 50% in all unit types.

Table 4. Results of Analysis of Universal Reach Range

Design element	Mean (Std)	Problematic cases
Height of bottom of wall cabinet	1,428.7mm (8.0)	11 (100%)
Height of countertop	855.6mm (5.4)	-
Depth of countertop	596.6mm (6.0)	-
Clearance between work surface and wall cabinet	573.1mm (10.0)	-
Obstruction by projected base cabinet	280.2mm (12.8)	10 (90.9%)

No case required wall modification or an increase in kitchen size to provide an additional countertop. In addition, no case met all requirements of clear floor space, work triangle, and countertop.

4.3 Universal Reach Range

The results of analysis of the universal reach range using eleven documents on kitchen wall elevations are shown in Table 4. Countertops were installed within the appropriate height and depth. However, the bottom of the wall cabinet was above the universal reach range suggested in this study. In addition, the projected base cabinet became an obstruction due to the difference in depth between the countertop and the wall cabinet. Therefore, it was highly expected that even if a pull-down shelf is installed inside the wall cabinet in order to meet the users' needs, it can be difficult to reach

the shelf due to the height of the wall cabinet and the projection of the base cabinet.

4.4 Area for Later Use

(1) Removable base cabinet

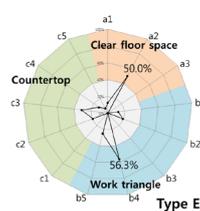
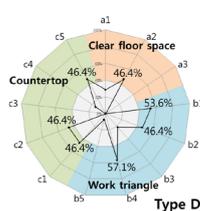
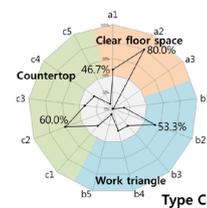
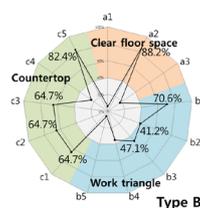
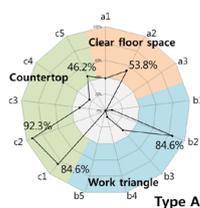
Because there was no case where a removable base cabinet was installed, only the condition for installation was investigated. In all cases, there was no barrier obstructing the forward approach of wheelchair users. Moreover, clear floor space for the T-shape turn was provided in front of the sink, and the centerline aligned with the centerline of the sink.

From the analysis of the documents on wall elevations, all sink base cabinets met the requirement of more than 900mm in width for a T-shape turn (mean width 954.5mm). Nevertheless, they did not meet the requirement of more than 650mm in height for knee

Table 5. Problematic Cases in Each Unit Type

Design element		Unit type (number of sample)					
		A (13)	B (17)	C (15)	D (28)	E (16)	
a. Clear floor space	1. Sink (parallel approach)	38.5%	5.9%	46.7%	28.6%	12.5%	
	2. Range (parallel approach)	53.8%	88.2%	80.0%	46.4%	50.0%	
	3. Refrigerator (parallel or forward approach)	-	17.6%	-	-	-	
	4. One or more problems (a.1-a.3)	69.2%	94.1%	86.7%	67.9%	50.0%	
b. Work triangle	1. Location of sink within work triangle	7.7%	70.6%	13.3%	53.6%	12.5%	
	2. Sink-range						
	<1,200mm	84.6%	41.2%	53.3%	46.4%	18.8%	
	>=2,700mm	-	-	-	-	-	
	3. Sink- refrigerator						
	<1,200mm	30.8%	11.8%	20.0%	7.1%	-	
>=2,700mm	-	35.3%	6.7%	14.3%	-		
4. Refrigerator-range							
<1,200mm	7.7%	35.3%	-	32.1%	-		
>=2,700mm	-	-	26.7%	25.0%	56.3%		
5. Total of the three legs							
<3,600mm	-	-	-	-	-		
>=6,600mm	-	5.9%	6.7%	7.1%	25.0%		
6. One more problems (b.1-b.5)							
		92.3%	100.0%	80.0%	92.9%	68.8%	
c. Countertop	Length of countertop	1. Sink and preparation center (>=900mm)	84.6%	64.7%	26.7%	46.4%	-
		2. Sink (>=460mm)	92.3%	64.7%	60.0%	46.4%	18.8%
		3. Range (>=80 or >=230mm)	30.8%	64.7%	33.3%	25.0%	31.3%
		4. Range (>=380mm)	23.1%	23.5%	26.7%	14.3%	12.5%
		5. Refrigerator (>=380mm)	46.2%	82.4%	6.7%	46.4%	6.3%
		6. One more problems (c.1-c.5)	100.0%	100.0%	80.0%	78.6%	50.0%
	Causes of problem	7. No problem	-	-	20.0%	21.4%	50.0%
		8. Location of sink or range	23.1%	23.5%	53.3%	50.0%	50.0%
		9. Location and size of sink or range	15.4%	17.6%	6.7%	3.6%	-
		10. Location of sink or range, total length of countertops	61.5%	58.8%	20.0%	25.0%	-
		11. Kitchen size or wall dimension	-	-	-	-	-
One or more problems (a.1-a.3, b.1-b.5, c.1-c.5)		100.0%	100.0%	100.0%	100.0%	100.0%	

Summary



clearance (mean height 630.1mm).

(2) Dish washer

A dishwasher was installed in 15 cases (16.9% of all cases) and the requirement of the distance from the edge of the sink was met in all cases. However, in 8 cases (53.3%), the dishwasher door intruded into the clear floor space for wheelchair users.

4.5 Safety

Seven cases (7.9% of all cases) where an operable window was installed above the range were investigated. In all cases, the window was placed too low and difficulties in opening the window and increased danger of accidents were highly expected.

4.6 Discussion

Results of the analysis of architectural documents indicate that it is most important to modify the layout of the sink, range, and refrigerator to provide appropriate clear floor space, work triangle, and countertops in apartment kitchens in Korea.

For a safe and convenient approach to the layout of appliances, the distance between the range and the adjacent wall needs to be increased in order to align centerlines between the range and clear floor space for a parallel approach. In addition, in the L-shaped kitchen, the distance between the sink and the corner of the counter should be increased.

To provide an efficient work triangle, the distance between the sink and range needs to be increased. In kitchens where the refrigerator is placed on the balcony, the layout of appliances should be modified in order to locate the sink between the range and the refrigerator within the work triangle. In addition, in some large kitchens, the distance between the refrigerator and range should be decreased.

To provide appropriate countertops for each appliance, the location of the sink and range should be modified. In addition, in some small kitchens, additional counters of approximately 300mm in length should be provided.

The height and depth of the wall cabinet and the depth of the counters also need to be modified, considering the reach range of various users. In addition, the knee clearance space provided in the removable base cabinet should be taken into consideration in determining the counter height and sink bowl size.

In determining the location for the later installation of the dishwasher, not only the clear floor space, but also the intrusion of the appliance door needs to be considered. The installation of an operable window above the range should be avoided if possible. When the installation is unavoidable, accident prevention needs to be considered.

As mentioned above, all design elements selected for the criteria of universal design in this study have strong relationships to each other. Therefore, for the application of universal design to kitchen design, various considerations are needed such as the size and

shape of the kitchen, the location of appliances such as the sink, range, refrigerator, and storage, as well as the design and layout of the clear floor space, work triangle, countertop, reach range, and knee clearance formed by the location of each appliance.

5. Alternatives for Five Cases

Cases for each of the five unit types, which had the typical problems of the unit type represented by shaded texts in Table 5., were selected and the results of analysis of each case were summarized. In addition, in terms of universal design, applicable alternatives providing appropriate clear floor space, work triangle, countertop, and area for later use (removable base cabinet, dishwasher, and pull-down shelf) without increasing the current kitchen size were suggested for each case. In suggesting alternatives, changes in fixture layout were minimized as much as possible and the installation of an operable window above the range was avoided. The thickness of the wall in the alternatives was 120mm or 200mm, and length of the sink bowl was 800mm, the length of the refrigerator was 900mm, and the lengths of the range and dishwasher were both 600mm. Table 6. shows the results of analysis and alternatives for each case.

(1) Case A1

In case A1, clear floor spaces for parallel approach to the sink and range were not provided and the counters for the sink and refrigerator were not appropriate. The distance between the sink and refrigerator and the distance between the sink and range were insufficient.

In the alternative kitchen, the location of the duct, refrigerator, sink, and range was modified and the countertop of 330mm in length was added.

(2) Case B1

In case B1, a clear floor space for parallel approach to the range was not provided. The sink was not located between the range and refrigerator within the work triangle, and the distance between the refrigerator and range was too short. The counters for the sink, range, and refrigerator were also not appropriate. The total length of the wall was insufficient for the fixture layout due to the small size of the kitchen and the two doors installed in the wall.

For the alternative, the type and width of the balcony door were modified and a gallery kitchen was suggested. The locations of the refrigerator, sink, and range were modified. The length of the sink bowl was modified to 750mm to provide appropriate counters. In this case, the countertops provided on both sides of the range could be longer than in other cases.

(3) Case C1

In case C1, clear floor spaces for a parallel approach to the sink and range were not provided. The counter for the sink was not appropriate and the distance between the sink and range was insufficient. In the alternative kitchen, the location of the refrigerator, sink, range, and tall cabinet were modified.

(4) Case D1

In case D1, a clear floor space for parallel approach to the range was not provided. The sink was not located between the range and refrigerator within the work triangle. The distance between the sink and range was also too short. Finally, the counters for the sink, range, and refrigerator were not appropriate.

For the alternative, the location of the refrigerator, sink, and range were modified with consideration of the location of the sink within the work triangle. The location of the duct was also modified due to the change in the location of the range. In addition, the balcony door was moved slightly to provide space for the refrigerator.

(5) Case E1

In case E1, the refrigerator was located too far from the range. In addition, the countertop for the range was insufficient. For the alternative, the sink and range were moved slightly.

6. Conclusion

From the perspective of universal design, the present study investigated the accessibility and usability of the apartment kitchen, which is one of the most important places in housing for independent living.

With the consideration of supporting the needs of various users as much as possible, five criteria for designing spatial dimensions and fixture layouts were developed based on research on the mobility of wheelchair users.

The result of the analysis of architectural documents demonstrated that fixture layouts in Korean apartment kitchens are typically difficult to navigate for wheelchair users. The location of the refrigerator, sink, and range typically needed to be modified to provide appropriate clear floor space, work triangle, and countertops. In some cases involving small kitchens, additional counters needed to be installed. Moreover, the height and depth of the wall cabinet and countertop, the size of the sink bowl, and the location of the dishwasher also needed to be modified.

This study suggested applicable alternatives for five unit types without increasing the current kitchen size. From this, the possibility for designing a more universal kitchen within the current kitchen area size has been demonstrated. Thus, it could be concluded that the usability and accessibility of the spatial layout of a kitchen would be more easily affected by the spatial distribution of appliances and the relationship between them than the size and shape of the kitchen.

Therefore, for the application of universal design to kitchen design, considerations not only of the size and shape of the kitchen and its appliances, but also of clear floor space, work triangle, countertop, reach range, and knee clearance formed by the location of each appliance are required.

According to the concepts of universal design, the lowered mobility capabilities of the elderly and the

Table 6. Results of Analysis and Alternatives for Five Cases

Results of analysis	Alternatives
A1	
B1	
C1	
D1	
E1	
<p>a. Problems with clear floor space b. Problems with work triangle c. Problems with location of sink within work triangle d. Problems with countertop</p> <p>1. Modified door or duct 2. Clear floor space 3. Work triangle 4. Countertop 5. Removable base cabinet 6. Space for dishwasher 7. Space for pull-down shelf</p>	

disabled are characteristics rather than impairments. If efforts are made to understand the characteristics of average and lowered mobility, it is possible to design fixture layouts within the same kitchen for various users. Therefore, based on the understanding of user characteristics in terms of mobility capabilities and the

spatial relationship between kitchen appliances, small considerations in the design process can make the difference between independent and dependent users.

Housing with specialized designs that accommodate spaces especially for users with limitations (e.g. public rental housing for the elderly and the disabled in Korea) is considered one option. But a better alternative is to make common housing more accessible, usable, and universal for the highest number of people with varied capabilities by providing appropriate layouts and optional spaces for adjustments such as removable base cabinets, pull-down shelves, and so on.

Universal design codes and guidelines developed in Korea contain general principles and guides for kitchen design, but they need to be complemented and clarified in terms of the usability of the kitchen, which might be affected by its work triangle composition, countertop distribution, etc. Findings in this present study could be used as basic material for universal kitchen design.

The criteria and alternatives suggested in this study should be complemented in terms of actual usage, users' needs, applicability, efficiency, etc. Further study on the usability of kitchens including the use of other appliances and furniture such as a dining table, pull-out counter, rolling cart, counters with varied heights, etc. will be considered.

Notes

¹ In our previous study (Kang and Lee, 2007), a method for applying universal design to bathroom designs in apartments was suggested. In this successive study, a similar research procedure was employed for analyzing the accessibility and usability of apartment kitchens.

² It means that this study aims to suggest kitchen design usable by most people including wheelchair users. It also means that it could be necessary to provide additional design measures for users with less motion capabilities than wheelchair users, e.g. persons suffering from arthritis or heart diseases.

³ The seven principles established by the Center for Universal Design guide a wide range of design disciplines such as products, environments, and communication. These principles are neither mutually exclusive nor easy to measure quantitatively. In this study focused on the design of spatial dimensions and fixture layout in apartment kitchens, five groups of design elements that were mutually exclusive and could be measured quantitatively were deduced.

⁴ Suggested dimensions for each design element were mainly based on the Korean domestic codes and industrial standards. Through a comparison with foreign codes and guidelines, the dimensions were modified and several criteria for design elements previously lacking were added.

Acknowledgement

This study was supported by a Korea University Grant.

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