User Analysis and Quality Function Deployment for the Design of Four-Wheeled Walker

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***Abstract*—Four-wheeled walker is one of the most important devices to assist old people's movement. We carried out user survey and analysis as a basic study for the design improvement of four-wheeled walker. For user analysis, phone interview was performed for one hundred aged users that have used four-wheeled walker for one year or more. And, depth interview was performed for twenty two aged users and observation method was used to get usability problems for four-wheeled walker. Through user analysis, aged users' requirements for the usability of four wheeled walker were identified, and then the quality function deployment (QFD) was applied to solve design problem. Finally, handle design was decided as the most important things of four wheeled walker.**

I. Introduction

Recently, old people rapidly go on increasing in number. So, it is very important to develop and evaluate senior friendly products due to increasing in old people. In the past, most of companies didn't have any interests for the development of senior friendly products. In these days, the increase of old people aroused international and company's interest and made the situation that development and study for senior friendly products could actively be carried out. In particular, the degradation of old people's physical and cognitive ability brought up the necessity of ergonomic study in the development of senior friendly product [1]. Usability problems of senior friendly products may cause a serious accident as well as the inconvenience of use to old people.

American National Safety Council announced that 50.7% of persons who died by an unpredicted accident at home was old people. Old people stay at home for the most time of day because he or she has declined in health, but there are many risk factors that are caused by unsuitable design for facilities and products. So, old people are always exposed oneself to danger for accidents.

In Korea, 2006, users above sixty years old encountered with more accidents than users below sixty in the process of product use. And, 57.2 percent of whole accidents were occurred at home, 14.7 percent was in public area, and 9.8 percent was on the road. In aspect of accident types, 55.3 percent of accidents were occurred by falls and slips, 7.5 percent by conflicts, 4.5 percent by getting a cut or being torn on the body with a thing, respectively. In aspect of body parts, 26.4 percent of accidents injured head and face, 24 percent to leg and foot, 18.1 percent to arm and hand, 14.7 percent to neck, abdominal region, back, and waist, respectively [2].

In this time, we can know that accidents related with a fall are above 50 percent. Therefore, aged users need a product to prevent an injury from falls.

In fact, most of old people suffer some difficult problems in walking because of the declined physical ability. Four wheeled walker is one of the most popular products to support aged users' walking.

In this world, there are many kinds of walkers for old people, but we can typically classify by three types; working frame, two wheeled walker, and four wheeled walker [1] as you can see in Fig. 1.

Fig. 1. Walker types: walking frame (left), two wheeled walker (center), four wheeled walker (right)

Although there are three types of walker, old people usually use four wheeled walker to move to somewhere in outside. However, we can not easily find a four wheeled walker that aged users' characteristics were considered in the design.

Therefore, we investigated and analyzed aged users' needs and usability problems and tried to solve design problem using quality function deployment (QFD).

II. User Analysis

It is not easy to get aged users' opinion for four wheeled walker. Old people don't want to expose their thought, psychologically. Sometimes they don't also recognize usability problems. In aspect of survey method, some of them don't express thoughts by writing.

In this case, interview is better method to get their opinion than literature survey. Also, observation method is effective to get usability problems because old people's recognition ability is not good.

In this study, phone interview, depth interview, and observation were carried out to get old persons' needs, usability problems, etc.

A. Phone interview

Phone interviews were performed to one hundred users that have used four wheeled walker for one year or more. As the results, eight nine of a hundred people answered that satisfy about satisfaction or dissatisfaction for four wheeled walker and eleven did dissatisfaction.

For use purpose (Fig. 2), persons who use four wheeled walker because waist is painful were 62 ones, and 37 persons answered to leg discomfort, 2 persons to osteoporosis, 5 persons to other opinions, respectively.

Fig. 3 is the frequency graph of aged users' needs for four wheeled walker. From the result, we can know what aged users want for four wheeled walker. Fig 4 is the frequency graph of points improved after using four wheeled walker. We can know what aged users are satisfied after using the walker.

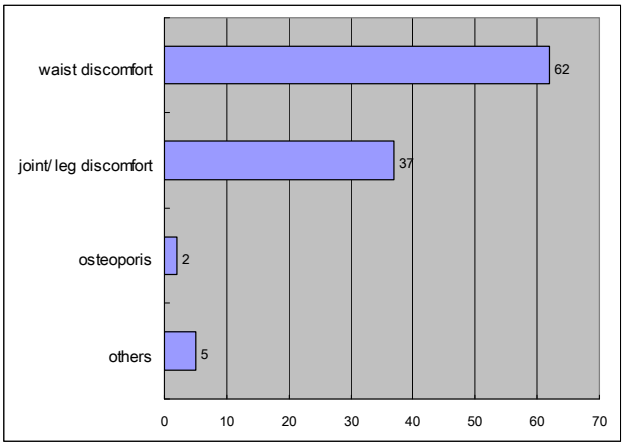

Fig. 2. Purpose using four wheeled walker

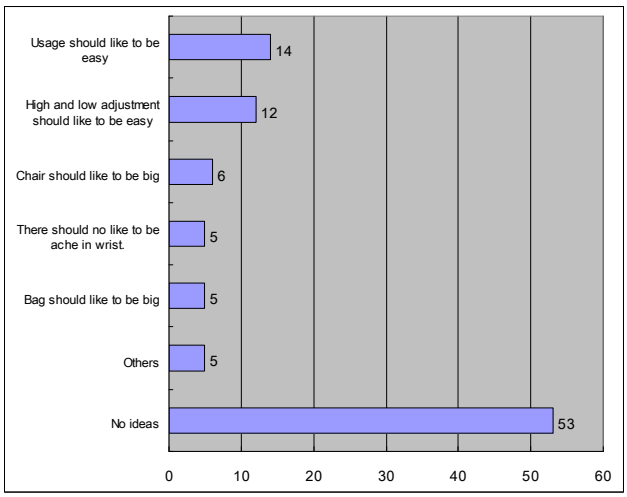

Fig. 3. The aged users' needs for four wheeled walker

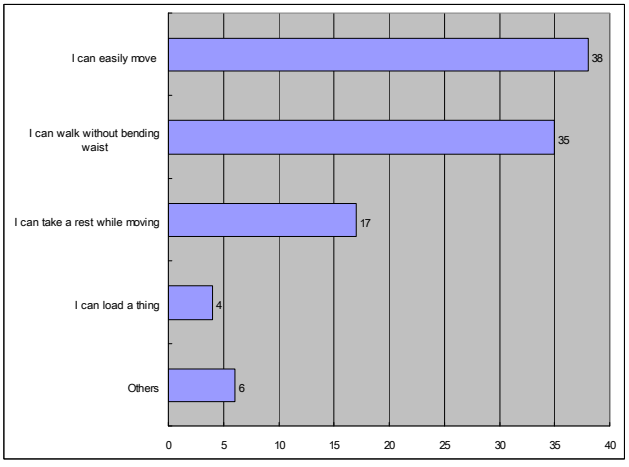

Fig. 4. Points improved after using four wheeled walker

B. Depth interview and observation

Depth interview and observation were performed at Chunhye Home for the Senior Citizens in Gwangju Metropolitan City, Korea. The aged users' needs and usability problems were surveyed in this interview and observation. Twenty two old persons participated in this interview and processes using four wheeled walker were observed. Of course, processes using four wheeled walker were recorded and analyzed by camcorder. Fig. 5 is scenes of interviewing and Fig. 6 is scenes of observation.

Fig. 5. Depth interview

Fig. 6. Observation

Usability problems for four wheeled walker collected through interview were not greatly different from ones of phone interview. Those are as follows.

- Three persons said a pain in the waist
- Five persons said a pain in the arm
- Three persons said a pain in the wrist
- Two persons said dissatisfaction about height control
- Two persons said discomfort for seat
- Two persons said discomfort for brake control
- One person said dissatisfaction about product weight
- Three persons didn't say their opinion

Scenes recorded by camcorder were analyzed through video analysis and the results are as follows.

- Balancing is not easy.
- Controlling brake is not easy.
- Posture is unstable.
- Wrist bending.

III. APPLING QFD TO DESIGN PROBLEMS

From phone interview, depth interview, and observation, eight requirements for four wheeled walker were finally selected for further analysis.

- Easy height control
- Comfort of waist
- Comfortable seat
- Light product weight
- Comfort of wrist
- Large bag

- Easy brake control
- Comfort of arm

In this time, QFD was applied to get design solution considering users' requirements. QFD is a method to transform user demands into design quality, to deploy the functions forming quality, and to deploy methods for achieving the design quality into subsystems and component parts, and ultimately to specific elements of the manufacturing process.

QFD helps transform customer needs (the voice of the customer) into engineering characteristics (and appropriate test methods) for a product or service, prioritizing each product or service characteristic while simultaneously setting development targets for product or service [3]. The process of QFD is as follows.

1. Identify customer needs and wants as voice of the customer (VOC)
2. Identify the engineering characteristics of products or services that meets VOC
3. Setting development targets and test methods for the products or services

In this study, QFD was applied to get design solution of four wheeled walker. As like in the previous section, we identified users' needs and usability problems for four wheeled walker through interview and observation. And then, we decided aged users' eight requirements for the walker.

Engineering characteristics (technical/design requirements of four wheeled walker in this study) were identified by the designer of four wheeled walker who has worked in this area for four years. Technical/design requirements were greatly classified to length, position, angle, shape. In detail, there were handle height, width between left and right handle, handle length, distance between fore and back wheel, angle of handle, etc.

Finally, we have to set development targets and test methods for the product or services. For this, HOQ (House of Quality) such as Fig. 7 have to be made. In this picture, technical correlation matrix evaluates how the defined product specifications optimize or sub-optimize each other. CTQ (Critical to Quality) is obtained from the matrix, then the result is used in the design of four wheeled walker.

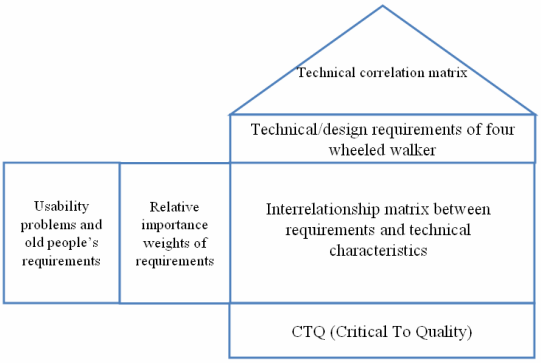

Fig. 7. House of Quality

In this study, AHP (analytic hierarchy process) which is a structured technique for helping people deal with complex decisions was used to get the relative importance weights of aged users' requirements. Specialists in biomechanics, ergonomics, mechanical engineering, and rehabilitation engineering participated in evaluation to get the relative importance weights using AHP.

Table 1. Relative importance weight of requirements

Aged users' requirements	weight
Easy height control	0.265
Comfort of waist	0.170
Comfortable Seat	0.045
Light product weight	0.075
Comfort of wrist	0.140
Large bag	0.024
Easy brake control	0.145
Comfort of arm	0.136

In order to determine the priority of technical/design requirements for design improvement, interrelationship matrix between users' requirements and technical/design characteristics was made by two specialists of four wheeled walker, and then the priority was determined integrating correlation scores and requirements weight as like in Fig. 8.

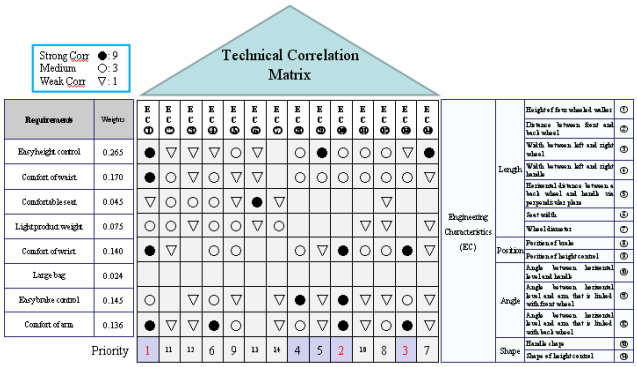

Fig. 8. HOQ applied to four wheeled walker

As the result, the most important technical/design requirement for improvement was handle height, and then angle of handle, handle shape, brake position, etc. In conclusion, the first part of four wheeled walker that has to be improved for aged users' usability is its handle because important design requirements identified from QFD were mainly related to handle.

IV. Basic Experiment to Evaluate Handle

Through user analysis and application of QFD, we concluded that the improvement of handle design was most important in four wheeled walker. In the future, we will newly design handle to meet users' requirements and evaluate its usability. As the basic study, we evaluated handles using EMG (electromyography), which involves testing the electrical activity of muscles.

Of course, this is a basic study to evaluate a new design of handle and to understand the evaluation method using EMG. For the experiment, we selected three typical handle types for four wheeled walker. Although the third type (Type C) was not a general walker, we included the model in this experiment because this experiment was a kind of basic study and we had considered it as a handle type of four wheeled walker.

Fig. 9. Experiment using EMG

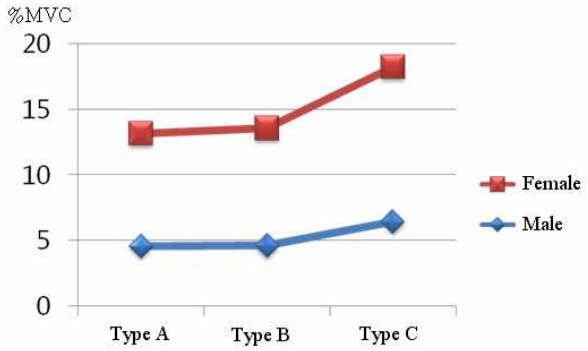

Fig. 10. %MVC with handle types

Fig. 10 is %MVC (Muscle Voluntary Contraction), which is the normalized EMG activity levels, with handle types. In this graph, high %MVC means high muscle load.

From the experiment, EMG provided kind of possibility to evaluate the suitability of handle design for four wheeled walker.

V. Conclusion

In this study, old people's needs and usability problems were identified from interview, phone survey, and observation. Then, we selected aged users' requirements for four wheeled walker through user analysis. We reviewed for the applicability of QFD to get design solution and ascertained that QFD could be effectively applied to design problem.

According the priority derived from applying QFD to users' requirements, it was ascertained that handle was the most important part in four wheeled walker.

In the future, we will design a new handle of four wheeled walker considering ergonomic aspects and evaluate its usability in comparison with existing ones.

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