

Functional Convergence factor and Usability Evaluation of The Range of Use of The Smart Automatic Urine Disposer

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스마트 자동 소변처리기의 기능적 융복합요소와 사용범위의 사용성평가

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Abstract Recently, devices that help the general public's urination activity have been developed, but products that take into account the user's urination habits, device functions, and user accessibility are still insufficient. This study conducted a usability evaluation to find user satisfaction and improvement points of products based on smart automatic urine disposer that have convergence and complex functions such as automatic suction functions. There are 21 indicators used in usability evaluation, and were developed based on safety, operability, and satisfaction. As a result, functional satisfaction was high, but in terms of design, problems to be improved such as handles were presented. Therefore, through this study, it was found that the satisfaction of the automatic urine disposer in terms of performance cannot be representative of the product, and the importance of developing usability evaluation index to find product problems.

Key Words : Urine disposer, Convergence factor, usability evaluation, usability evaluation index, satisfaction

요약 최근 일반인의 배뇨활동에 도움을 주는 장치가 개발되고 있으나, 사용자의 배뇨 습관과 기능, 사용자의 접근성 등을 고려한 제품은 부족하다. 본 연구에서는 배뇨활동에 도움을 주는 장치 중 자동 석션 기능 등 융, 복합 기능을 지니고 있는 스마트 자동 소변처리기를 기준으로 사용자의 만족도와 제품의 개선점을 찾고자 사용성평가를 실시하였다. 개발된 사용성평가 지표는 모두 21개이며, 안전성과 조작성, 만족도를 기준으로 개발하였다. 그 결과 기능적인 만족도는 높았으나, 디자인 측면에서는 손잡이 등의 개선해야 할 문제점이 제시되었다. 따라서 본 연구를 통해 자동 소변처리기의 성능측면의 만족도가 제품을 대표할 수 없으며, 제품의 문제점을 찾기 위한 사용성평가 지표 개발의 중요성을 알게 되었다.

주제어 : 소변 처리기, 융복합적 요소, 사용성평가, 사용성평가 지표, 만족도

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1. Introduction

Recently, an increase in the elderly population due to the aging of the population and the number of subjects who are difficult to urinate alone due to acquired disabilities such as disease and accidents are increasing. According to a report from a related agency, the number of subjects in 2019 was 2.61 million, accounting for 5.1% of the total population[1]. Currently, about 4.5% of the population needs help from people such as carers[2]. Therefore, the number of people who mainly use disposable diapers as a method of urination that can be solved by themselves without assistance from the surroundings is increasing[3,4]. Diapers are easy to wear, and have the advantage of being disposable in terms of personal hygiene, but they have a problem that can be known only by checking the presence or absence of urination from the outside, and a problem that must be changed frequently[5]. Therefore, if the patient's discomfort and urination are not handled immediately due to the delay in the replacement of diapers, problems such as the pressure ulcer and hygiene caused by secondary infection may occur[6]. Currently, 2.5 billion diapers are consumed per year, and all of them are landfilled and incinerated as household waste, so social resources are wasted and environmental problems are also present[7]. In order to physically solve this problem, the smart automatic urine disposer has been recently developed in various types, and the demand is increasing due to the record of urination activity of urinary patients and the increase of external activities of the disabled[8,9]. Rather than that the device was developed based on simply inpatients who are hospitalized and treated, the demand for development is increasing because conscious patients and related subjects can use it for a purpose to cope with diapers when needed for a short period of time.

In general, a person performs an average of five to six urinary activities a day, and the amount of urine measured in one micturition activity is about 250 to 300 cc. It can be called polyuria if it is more than 3,000 cc per day, and urine reduction if it is less than 500 cc per day[10-12]. Humans continuously perform urination activities to maintain the homeostasis of the human body, and physical tools such as diapers or urine disposer are required depending on the physical situation. The smart automatic urine processor is a tool that can solve this problem, and in this study, we intend to develop a usability evaluation index to quantitatively evaluate how this kind of product helps users.

The usability evaluation for such household goods is helping to quantitatively evaluate the qualitative factors of individual users by evaluating the effectiveness, efficiency, and satisfaction of the product. This study was to evaluate by referring to the usability evaluation guideline of ISO (International Organization for Standardization) 9241 Part 11, and usability evaluation was conducted for the purpose of finding the improvement points of the product produced as a prototype[13,14]. The proposed product has a urine disposing function and a urine test function corresponding to a medical test. In this study, an evaluation index was developed based on the subject's urine treatment function, and the results of usability evaluation were analyzed.

The smart automatic urine disposer is manufactured according to the physical characteristics of urination for men and women. This study was conducted to suggest problems by developing usability evaluation index based on accessibility such as ease of use, excluding ergonomic evaluation of functional cups (urine trays). The evaluation was set as the ultimate research objective to derive the improvement points of the developed smart automatic urine disposer product by performing both objective

evaluation and subjective evaluation at the same time.

2. Materials and methods

This study developed the usability evaluation index of the smart automatic urine disposer through preliminary literature research and product analysis, and the effectiveness and validity of the evaluation index were verified through experts. In addition, the trial product was finally evaluated for the elderly. In addition to the objective questionnaire, subjective evaluation was also conducted through interviews with subjects after use to find problems with the product. The research procedure was carried out as shown in Fig. 1.

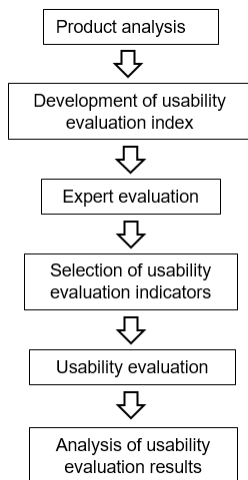


Fig. 1. Usability evaluation sequence

The product of the automatic urine disposer is consists of devices, hoses, and urine cups (male and female) with suction function of excreted urine, urine volume measurement, number of urination, and device management and control functions. The shape of the product is shown in Fig. 2.



Fig. 2. Product composition of smart urine automatic processing machine

The users selected elderly people who are uncomfortable with physical movements, and especially, 10 elderly people who cannot use the toilet at night were selected as subjects. Users with a MMSE-K cognitive ability scale score of 27 or higher without neurological damage and no cognitive problems were selected, and the general characteristics of the subjects are as shown in Table 1[15]. In this study, the principle of self-use of urine disposer was established, and evaluation of caregivers, etc. was excluded from this assessment as users were allowed to use them for at least 20 days. Therefore, this usability evaluation aims to find as many product problems as possible through those who need this product.

Table 1. User characteristics

Characteristic	User	
	Man	Woman
Number	8	2
Average age	70	71
Height	164	145
Weight	75	68
MMSE-K	28.6	

The usability evaluation index development was developed based on the stability, operability, and satisfaction of the product to be tested. First, for stability, the problem of whether there is excessive damage to the body or damage to the surrounding area was examined when using the

product. As the elderly or subjects with physical difficulties use this product, evaluation factors such as perception of device operation and actual operation were developed with an emphasis on the use and operation of the product. Finally, in order to derive a result that meets the purpose, an evaluation index for the effectiveness of the product was also developed. Through this, evaluation factors to verify the satisfaction of the product were presented.

In addition, after using the product, subjective evaluation through individual interviews was performed for each subject to provide objective data on product-related problems. For the usability evaluation index developed in this study, the evaluation questions were written on the Likert 5-point scale (very yes, yes, moderate, not very, very not) so that the subject had no difficulty in evaluating[16]. The main evaluation items and contents are shown in Table 2.

In addition, it was verified whether the

usability evaluation index developed for the smart automatic urine disposer was a valid tool as a measurement tool. Mainly in the case of welfare equipment, the questionnaire question proposed in consideration of the subjective evaluation factor and the specificity of the user may lack objectivity, so the validity of the usability evaluation index question was verified for experts. The experts consisted of 3 engineers, 5 nurses, and 2 caregivers, a total of 10 people, and were made up of more than 10 years of experience in related fields.

Content validity is evaluated by an expert on whether the indicator clearly states the concept to be generalized and whether it comprehensively covers the concept to be measured. The content validity of the evaluation items was evaluated by making a Likert 5-point scale (very valid, valid, moderate, insufficient, very insufficient) whether the questionnaire items of the usability evaluation index presented to the user are valid.

Table 2. Usability evaluation index

	Domain	Attribute	Assessment indicator
1	Safety	Self-reliance stability	It is self-reliant without use
2		Safety of use	It does not fall or separate during use
3		conduction risk	There is no risk of conduction when used on a bed.
4		component stability	There is no risk of hose or cup separation during use.
5	Operability	cup handle	It is convenient to position.
6		handle orientation	It is easy to orient the urine handle attached to urine cup.
7		Grab the handle	It is reasonable in size and easy tp hold to handle.
8		Suction operation	It is comfortable to get urine after operation.
9		Hose folding	It is convenient to fold and organize the hose after use.
10		Spread hose	It is easy to open the hose during the preparation process.
11		Controlling the urine collection	It is easy to adjust the height when using it lying down.
12		Manipulate the urine outlet	It is easy to operate the outlet to throw away urine.
13	Satisfaction	Simplicity of operation	It is simple to operate the bulletin board.
14		familiarity	It is familiar type.
15		Ease of movement	It is not too heavy to move
16		carrying handle	It is convenient to hold the handle when moving.
17		Urine volume recognition	It is easy to read the scale to measure the amount of urine.
18		Urine color observation	It is easy to measure urine colors and foreign substances.
19		Physical synthesis	It is comfortable when used without any strain on the body.
20		Urine adjuvant	It is easy to pee
21		Noise	It is not noisy

Content validity was analyzed as Eq 1 based on the content validity ratio (CVR) suggested by Lawshe[17].

$$CVR = \frac{N_e - \frac{N}{2}}{\frac{N}{2}} \quad \text{-- Eq 1.}$$

N_e = The number of participants who consider the question valid

N = Total number of participants

The evaluation was conducted through the usability evaluation index of the smart automatic urine disposer derived through reliability verification. The most commonly accepted principle for calculating the number of subjects for usability evaluation is described as a general Magic Number 5, and if the number of subjects for user evaluation is 5, it is sufficient to find problems with the product[18]. It is said that the probability of finding a problem with only 5 evaluators is 80% or more, and up to 90% with 10 participants[19]. Therefore, in this study, 10 elderly people were evaluated.

3. Results

The usability evaluation index developed as a result of this study was evaluated in 21 items. The content validity of the item was reviewed through expert evaluation, and the minimum ratio for the item validity in previous studies is proposed as 0.56. As the result of the evaluation of the validity of the expert content in this evaluation, the minimum ratio was 0.601, so the questionnaire items in the usability evaluation index were confirmed to be valid[20].

Table 3 shows the results of the subject's usability evaluation. In the stability evaluation of the product, most of the users evaluated it highly after use. It is judged that this is because the

product is rectangular and the bottom is highly stable. In terms of operability, the urine receiver cup and the handle connected to it were evaluated low, and this is believed to be due to the connection with the control part. The handle part had to be made large in consideration of the hand movement of the elderly, but a problem was presented that was made in consideration of only the size of the fingers by emphasizing only the design aspect. In terms of satisfaction, overall high evaluation came out. In addition, there was no physical discomfort in use, and it was investigated that there was no discomfort when moving. The score was evaluated based on the Likert 5 point scale and was rated 4.33.

In subjective interview opinions, opinions on the safety of products and the prices of products accounted for the most, and opinions on disinfection and cleaning issues were also presented.

Table 3. Usability evaluation index evaluation result

	Domain	Attribute	Average
1	Safety	Self-reliance stability	4.25
2		Safety of use	4.21
3		conduction risk	4.36
4		component stability	4.36
5		cup handle	4.21
6	Operability	handle orientation	4.25
7		Grab the handle	4.25
8		Suction operation	4.36
9		Hose folding	4.21
10		Spread hose	4.21
11		Controlling the urine collection	3.75
12		Manipulate the urine outlet	4.12
13	Satisfaction	Simplicity of operation	4.36
14		familiarity	4.56
15		Ease of movement	4.75
16		carrying handle	4.21
17		Urine volume recognition	4.36
18		Urine color observation	4.36
19		Physical synthesis	4.75
20		Urine adjuvant	4.75
21		Noise	4.36

4. Discussion

In the case of a product that solves physical discomfort, satisfaction is generally high only when the user properly recognizes the product and can use it freely. This study attempted to perform the most basic evaluation of the product, assuming that a product manufactured to solve the most basic urination problem of humans can increase the frequency of reuse only when the user's satisfaction through basic recognition such as product use is high. In this experiment, the difficulty of operation was not high in the use of the product, and the complexity of the function was also low. Therefore, evaluation items were developed through the attributes of three indicators of stability, operability, and satisfaction, and the validity of the questionnaire was also tested. This study was conducted to improve user satisfaction by discovering product problems firstly and improving problems when producing mass-produced products in the future.

In usability evaluation, there is a difference between subjective and objective opinions, and this is mainly a problem stemming from personal usage habits rather than usability problems[21]. Since the improvement of these products also affects the usability evaluation results, products that solve physical difficulties, such as welfare equipment, require sufficient explanation and training on how to use them when using them. In addition, problems arising in this process should be applied to the main evaluation by referring to subjective opinions rather than objective opinions.

Developing products for use by the elderly in consideration of users and environmental factors through usability evaluation is consistent with the purpose of usability. In addition, it plays a role of enhancing product completeness and user friendliness by applying expert evaluation such as heuristic evaluation[22]. Therefore, such

evaluation can broaden the evaluation factors that have previously depended on performance evaluation, and can apply a wide range of targets to the product market. Although the main users of this product were the elderly, experts suggested that it is a product that can overcome temporary obstacles and that young people and infants also use it a lot. Therefore, there are limitations on product evaluation by age group.

In the case of such a product in the future, the functional aspect that can increase user accessibility should be considered rather than improving satisfaction due to performance evaluation. In addition, the usability evaluation through this experiment cannot be represented as evaluating the performance of the product, and the overall satisfaction of the product, such as design taking into account accessibility, should be evaluated as a quantitative figure. Therefore, it is very important to develop usability evaluation indicators, and it is necessary to develop indicators that consider all areas described above. In the development of the usability evaluation index of the smart automatic urine disposer, usability evaluation items were presented based on the three indicators of product stability, operability, and satisfaction. The presented indicators can be understood as conditions under which problems can be found when using the product.

5. Conclusions

In this study, 21 indicators of usability evaluation of smart automatic urine disposer that help the elderly with urinating activities were developed, verified, and the procedures and evaluation results were presented. In addition, the direction of product improvement through usability evaluation presented a quantitative result of accessibility in terms of design rather than functional aspects. Therefore, the overall

functional satisfaction and the degree of operability such as handle size were presented as objective results, and in the case of products used by the elderly in the future, it was explained through the usability evaluation results that the product is presented based on accessibility in use rather than performance. The number of subjects for usability evaluation in this study was 10. Since this is limited in generalization, it will be necessary to proceed with the study using sufficient sampling in future studies.

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