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Development and usability test of transfer device with customized sling lifts

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Abstract

Background: Bedridden patients and disabled persons need help from a guardian or caregiver even in performing simple activities of daily living. In particular, for body transfer of them, the use of a transfer lift has been recommended. However, the devices currently in use have limitations in terms of support according to the individual's characteristics. This study aimed to develop a transfer lift device utilizing the patients' body-fitting sling equipped with an air tube inside the sling. In addition, we have conducted usability tests to examine the safety, effectiveness, and satisfaction with this device.

Design: This study conducted usability tests with 10 healthy adults.

Methods: Customized sling lifts are generally floor-based devices that consisted of a sling that holds the patient's body and a lift that moves the sling to the desired position. One characteristic feature of the device is an air tube, which is used on the sling to allow the patient's body can be adjusted. A usability test was performed in terms of the operators, who operated the device to transfer the patients. Ten operators tried the device and tested its usability.

Results: The mean of 10 question for Questions was 4.18.

Conclusion: The device can be useful in the advancement and commercialization of customized sling lifts, to ensure the safe and efficient transfer of persons with disabilities.

Key words: Transfer device, Customized sling lifts, Bedridden.

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Ⅰ. Introduction

Various types of the activities of daily living (ADL) such as bed-to-chair transfer, walking, and stair climbing should be accompanied by independent physical functions (Prohaska et al., 2011). However, bedridden patients and disabled persons need help from a guardian or caregiver even in performing simply the ADL. The manual transfer may require repeated and unreasonable efforts, it gives the caregiver a physical burden, which may lead to the occurrence of injuries and musculoskeletal problems(Silvia et al., 2002; Andersen et al., 2014; Gomaa et al., 2015; SinHO Ha, 2022).

Recently, the use of a transfer lift is considered to decrease the physical burden that can occur when a caregiver changes a patient's body position or provides a transfer. Most transfer lifts used currently for general purposes are mainly focused on the type of device parts like ‘control device,’ or ‘lifting device’ or mechanical mechanisms, and there are insufficient development and research on the ‘body-support unit’ element that the patient's body can be supported through contact with the equipment.

In other words, there is differentiation only in the type, size, and weight of the part of the transfer lift products; however, they commonly use a carrier blanket-shaped flat fabric cut to a certain size generally called a 'sling' for the ‘body-support unit’ on which a patient is mounted. To support or mount the patient's body when using a transfer lift, the subject is laid on or covered by the sling, and the hook of the sling is connected to a part of the device to transfer him or her with hung in the air. In this situation, the center of gravity gets higher since the subject is hanging in the air, and the patient's anxiety during the transfer increases as the operator is shaken back and forth or side to side (Kim et al., 2009). In addition, if the patient is positioned in the sling without being fixed, the subject’s weight may not evenly distribute and excessive pressure can be concentrated on specific areas of the body.

Jung et al. made three kinds of suggestions for the direction of the development of transfer lifts through an analysis of transfer lift operators (Jung et al., 2010). One of them is concerned with the sling, which is a body-support unit form mostly used in transfer lifts and greatly affects the overall feasibility of the transfer lifts, and since the risks that may occur in using the transfer lift are mostly related to the sling. Thus, they suggested that it would be necessary to develop the function of the sling, sufficiently considering the physical characteristics of the operator so that the patients can feel comfort and ease when they are mounted on the sling (Jung et al., 2010). However, the sling of the transfer lift is still used currently as a simple woven fabric cut to a formal size, and most of the shapes and functions are all similar, which may cause pressure on specific body parts, it can make skin damage and displeasure, etc.

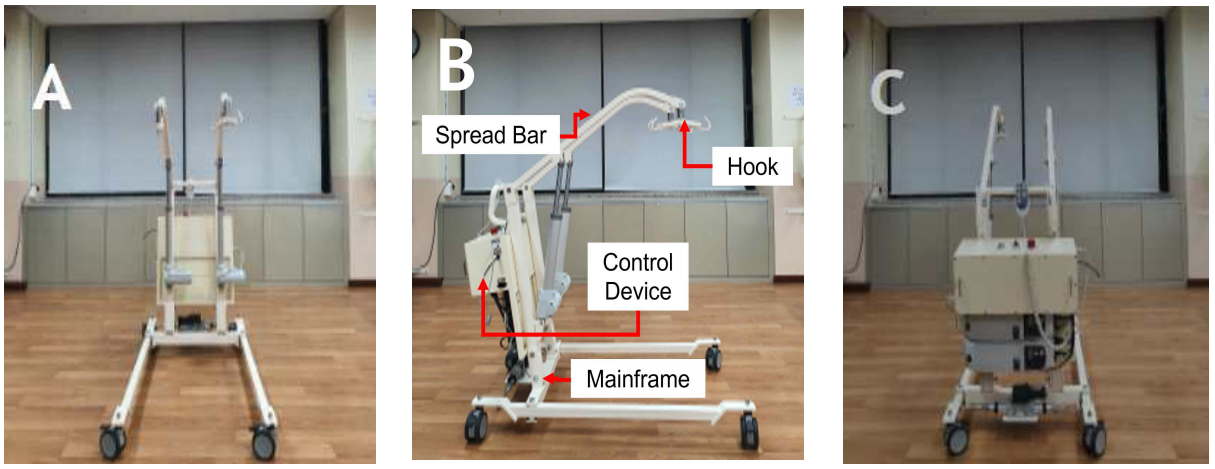
Therefore, this study developed a transfer lift device utilizing the patient’s body fitting sling equipped with an air tube inside of the sling so that the patient’s body weight could be evenly distributed while the patient mounted on the sling would not feel anxiety or discomfort during the transfer. By evaluating stability, effectiveness, and satisfaction through the usability test, we intend to provide a reference for future development and commercialization of the equipment developed in this study. In addition, we intended to develop equipment for safe and efficient body transfer of bedridden patients and disabled persons.

Ⅱ. Methods

1. Transfer lift device utilizing the user's body fitting sling

1) Composition of the device

This study developed a transfer lift device, utilizing the user's body fitting sling which belongs to the floor-based lift type. The developed device consists of the mainframe, air-tube sling, spreader bar, control device, and remote controller. The mainframe is a 'staple'-shaped metal structure that supports the patient's weight, and the wheels for the transfer of the device are attached to the bottom of the four vertices of the frame (Fig 1). The air tube sling is a part that makes the patient feel comfortable and improves the sense of stability when the patient's body is mounted inside the equipment (Fig 2). The spreader bar is a structure in the form of a horizontally long bar connecting the air tube sling and the mainframe, and both ends consist of each hook to connect to the air tube sling. The control device controls the height of the spreader bar to lift and lower the patient. The remote controller is composed of a button type and has a function to adjust the height of the equipment.



A: Front view of transfer device with customized sling lifts

B: Side view of transfer device with customized sling lifts

C: Rear view of transfer device with customized sling lifts

Figure 1. Transfer lift device

2) Device operation

In the transfer lift device utilizing the patient's body fitting sling, the mainframe, spreader bar, and control device are the mechanical part while the air tube sling is the mount part. To operate this device, first, the air tube sling must be applied to the patient's body. The patient is to be transferred, he or she is laid on the air tube sling, and the air injecting nozzle of the air tube sling is connected to the air compressor included in the control device. Inject air into the air tube sling to bring the sling into contact with the patient's body. After the proper amount of air is injected, remove the nozzle and hang the air tube sling connected to the spreader bar on the hook. As mentioned above, when the preparation process for patient transfer is completed, the operator can use the button of the remote controller to

lift the patient from the ground or floor, move to the desired location, and put the patient down.

Before air injection　　After air injection

Figure 2. Customized sling lifts

2. Usability test

1) Participants and procedures

This study conducted usability tests with 10 healthy adults. The participants were recruited through an offline bulletin board of a university, and a total of 10 operators volunteered. Before conducting usability tests, first, the participants' basic information (sex, age, height, and weight) was collected. The general characteristics of participants are as follows. By sex, seven were men, and three were women. The average age was 25.9 years old; the height, 169.6cm; and the weight, 62.2kg. Then, each participant was asked to directly operate the device, and the usability of the device was investigated.

2) Data collection and analysis

The usability test for the transfer lift device was conducted in the form of answering a questionnaire about how to use it after fitting the air tube sling to the patient's body. The questionnaire consisted of 10 questions and was surveyed by selecting answers on a five-point Likert scale. The five-point Likert scale consisted of 5 points for 'very satisfied', 4 points for 'satisfied', 3 points for 'normal', 2 points for 'dissatisfied', and 1 point for 'very dissatisfied'. The details of the test sheet for usability are described in Table 1. For statistical analysis, SPSS 18.0 version (SPSS Inc., Chicago, IL, USA) was used. The participants' basic information and the data collected through the usability tests were analyzed with descriptive statistics.

Table 1. Usability test Survey form

No	Questions	Scores				
1	Is the time required to apply the sling to the patient?	1	2	3	4	5
2	Is the time required to release the sling from the patient?	1	2	3	4	5
3	When lifting the patient after applying the sling, is the speed of ascent appropriate?	1	2	3	4	5
4	Is the descent speed appropriate when lowering the patient after applying the sling?	1	2	3	4	5
5	Is the vibration of the device appropriate when the patient is lifted and moved to another location?	1	2	3	4	5
6	Is the weight appropriate when moving the device?	1	2	3	4	5
7	Is the height of the device appropriate?	1	2	3	4	5
8	Is the device's design convenient to use?	1	2	3	4	5
9	Is the noise of the device appropriate?	1	2	3	4	5
10	Are the device brake locations and shapes appropriate?	1	2	3	4	5

1: Very dissatisfied, 2: Dissatisfied, 3: Neutral, 4: Satisfied, 5: Very satisfied

Ⅲ. Results

The results of the usability test are as follows. The mean (range) of each question for Questions 1 through 10 of the results 4.1 (3-5), 4.3 (3-5), 4.4 (3-5), 4.5 (4-5), 3.7 (2-5), 3.7 (2-5), 4.4 (4-5), 3.9 (2-5), 4.4 (4-5), and 4.4 (2-5). The overall mean of all questions was 4.18.

Ⅳ. Discussion

This study developed a transfer lift device utilizing the patients' body fitting sling to safely and efficiently transfer bedridden patients and disabled persons who have mobility difficulties and conducted usability tests to evaluate the safety, effectiveness, and satisfaction with the developed device. The average usability test was 4.18, and answers of 'satisfaction' or higher were revealed.

The transfer lift device utilizing the patients' body fitting sling in this study belongs to a floor-based and consists of the mainframe, air-tube sling, spreader bar, and control device. This device is characterized by the fact that it allows customized adjustment according to the patient's physical characteristics by building an air tube inside the sling, unlike the general fabric type in which the sling on where the patients are mounted simply supports the patient's body. The main metal frame is integrally constructed to prevent deformation of this equipment when the patients got on. In addition, wheels are installed at the bottom of the main frame for smooth positioning of the device. The spreader bar is installed in a long horizontal direction and serves to connect the air tube sling and the main frame, hook-shaped rings are installed on both ends for connection to the sling. And the control device is the part that operates the functions

of lifting and lowering the transfer lift.

The equipment developed in this study has a structure similar to a general floor-based lift, however, the difference from the existing lift equipment is that it uses an air tube sling when the patient is mounted. The slings of the floor-based lifts used in most studies are made of a carrier blanket-shaped fabric cut to a certain size, which has a merely one-dimensional function simply covering the patient's body. The sling of the floor-based lift used by Waters et al. to evaluate the safety and efficiency of the floor-based lift and overhead lift is a typical sling using carrier blanket-formed fabric (Waters et al., 2012). Another study also used the sling with flat fabric cut to a certain size for the floor-based lift (Marras et al., 2009; Rice et al., 2009; Zhuang et al., 1999). As such, the existing equipment focused on the operation method of the parts whether it is floor-based or overhead type, and did not discuss the sensation felt by the patient by the sling when the patient was mounted.

The issue of when bedridden patients or disabled persons whose physical function is deteriorated are put on a transfer lift should not be overlooked. An in-depth consideration of this part is needed when developing equipment to move patients who have difficulty moving according to their own will due to a decrease in physical function.

Jung et al. note that the aged show characteristics of noticeably deteriorated aspects in sensory function, motor function, and learning ability compared to younger and middle-aged adults, it is essential to approach, sufficiently considering their characteristics in developing products for people who have difficulty moving their own body (Jung et al., 2010). Thus, in this study, it is considered that the meaningful result is that more emphasis was placed on the development of the sling type of transfer lift device to make the patient feel more comfortable and stable when they mounted on the equipment.

A previous study on transfer lift development and usability test conducted the development of a multifunctional power lift utilizing the fixed bed in the bed shape instead of a fabric material like a sling or harness in the part on which the patient is mounted (Kim et al., 2009). Another study developed a swivel type-transfer lift applying the rotatable bed on the mounting part to which an aged person gets on to reduce the physical burden of the caregiver for the aged person, and to test the effectiveness of the bed rotation function, a usability test was conducted through a comparison of the subject’s muscle activity according to whether there is the bed rotation function. They reported that the operator's operability was relatively high and decreased the care cost of the operators compared to existing devices. This study developed a transfer lift device utilizing the patients’ body fitting sling that could allow customized adjustment of the body pressure distribution of the sling according to the characteristics of the patient's body mounted on the sling and conducted usability tests. In the usability test, more than average 'satisfaction' results were obtained, and it is considered that the development and commercialization of transfer lifts with patients' body-fitting slings can be expected. In addition, safe and efficient body transfer of bedridden patients and disabled persons in clinical and home settings will be possible.

However, there may be a few limitations in a comparison with previous studies. First, the previous studies extracted quantitative data values, using a test tool other than questionnaires in the usability tests while this study only used questionnaires consisting of single-choice type questions as a usability test tool. Second, the users who participated in the usability test were ordinary adults. The usability test should conduct to evaluate the users' highly relevant to the applicable product or service according to the user-centered approach to be able to draw improvements more accurately (Turner et al., 2006). And yet, this study may have several limitations in that it was conducted with ordinary adults

with somewhat less relevance to the transfer lift device. Thus, in the future, it would be necessary to utilize various usability test tools, and studies considering the criteria for selecting evaluation participants sufficiently should be conducted.

Ⅴ. Conclusion

In this study, a transfer lift device using a sling customized to the user's body was developed and usability evaluation was conducted, the key is to embed an air tube inside the sling so that it can be customized according to the user's body characteristics. From the result, it will be possible to achieve advancement and commercialization of a transfer lift device using a sling customized to the user's body in the future, and it will be able to be used safely and efficiently for the movement of patients or disabled people.

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