CLINICAL EVALUATION OF THE PROTOTYPE ROBOTICBED IN AN EXPERIMENTAL ENVIRONMENT

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INTRODUCTION

In order to use assistive technologies as a means for enabling elderly and disabled persons to lead a better life, requisite assistive technologies must be developed. In addition, clinical evaluations of novel assistive technologies are required from an early stage of development.

We previously proposed a methodology for the comprehensive clinical evaluation of novel assistive technologies. This methodology consists of four steps: 1) evaluation by rehabilitation professionals; 2) evaluation by potential users in a simple setting; 3) evaluation by users in an experimental environment; and 4) evaluation by users in a real-life environment [1]. In this study, we evaluated Roboticbed based on this comprehensive methodology of clinical evaluation. In addition, we identified three types of potential users using Step 1, and the manner in which Roboticbed can be used effectively by each of these users has been confirmed using Step 2 [2].

Roboticbed (developed by Panasonic Corporation) is a novel assistive technology in the development phase. As shown in Fig. 1, the main function of this bed is the provision of assistance in transferring a person with disabilities from a bed to a wheelchair, and the facilitation of easy indoor mobility [3]. It is expected that this bed will help the disabled to carry out their daily-life activities with ease and improve their quality of life. However, as Roboticbed is a novel concept in assistive technology, there are no established criteria for its clinical evaluation; furthermore, it is difficult to identify target users, set evaluation criteria,

Bed mode ⇒ Recliner mode ⇒ Wheelchair mode

Fig. 1 Roboticbed positions

and identify the risks involved in the use of the bed, and devise means for the effective use of this technology.

The purposes of this study are to identify the problems of using Roboticbed in an experimental environment, and then to evaluate Roboticbed based on our proposed methodology for comprehensive clinical evaluations.

METHOD

Experimental conditions

We extracted two categories of participants who meet the experimental conditions based on the results of Step 1: those who seek greater autonomy; and those who frequently have to move from a bed to a wheelchair. We extracted three categories of experimental use situation in an indoor barrier-free space based on the past findings of Step2: transfer from a bed to a wheelchair, indoor mobility and conduct activities in a seated position (e.g. hand working, drink water, watching TV) by using Roboticbed [1, 2].

Method

The participants were six persons with disabilities and their families/caregivers. Tables 1, 2 show the profiles of participants and their families/caregivers. This experiment involved two steps: an observation of action; and a questionnaire phase. The observed action step was performed in the experimental setup shown in Fig. 2. The actions of the participants were recorded by video cameras. In specified assignments, the participants were instructed to perform the following 15 tasks: 1) Lie down on the bed. 2) Move from the bed to the wheelchair. 3) Move to the work table. 4) Perform activity at the table. 5) Go out of the bedroom. 6) Move to the corridor. 7) Enter the living room and close the door. 8) Move to the living room table, staying clear of the chair. 9) Perform activities (drink water and watch TV.) 10) Move toward the exit. 11) Open the door. 12) Return to the corridor. 13) Enter the bedroom and return to the initial position. 14) Move from the wheelchair to the bed. 15) Lie down on the bed.

For the questionnaires, the Quebec User Evaluation of Satisfaction with Assistive Technology (in Japanese) (QUEST) [4], the Psychosocial Impact of Assistive Devices Scale (in Japanese) (PIADS) [5], and a subjective questionnaire on Roboticbed were used. This subjective evaluation was created based on the findings of Steps 1 and 2, and the questions consisted of 12 items with an 11-level rating system.

Analysis

An analysis of the observation of action was performed by counting the number of support, malfunction, and risk images recorded by the video cameras. The questionnaires of the score were used aggregate analysis

RESULTS

Results of the observation of action

The results of the observation of action are divided into: number of support actions, number of malfunctions, and number of risk situations, and are shown in Tables 3, 4 and 5.

Table 3 shows the number of support actions by Roboticbed. At the time of transfer, there were many instances of support to participants in Cases 2-6. During times of mobility, Case 1 had many instances of care by verbal experienced by Roboticbed. All the participants

Table 1 Profiles of participants

ID	1	2	3	4	5	6
Gender	F	M	M	M	M	M
Age	61	20	63	73	62	45
Disease	rheumatoid arthritis	muscular dystrophy	inherited neuropathy	perkinsonian syndrom	cervical cord injury	cervical cord injury
FIM (moter score:91)	49	33	18	49	49	49
Type of whellchair	powerd (add on power unit)	powerd, manual	powerd	powerd (add on power unit)	powerd	powerd
Use of place for wheelchair	indoor, outdoor	outdoor	indoor, outdoor	indoor, outdoor	indoor, outdoor	indoor, outdoor
Use of bed	use	non-use	use	use	use	use
Use of lifter	non-use	non-use	use	non-use	use	use
Living place	home	home	home	nursing home	home	home

Table 2 Profile of participants' families/caregivers

ID	1	2	3	4	5	6
Gender	M	F	M	F	F	F
Age	60s	40s	30s	70s	50s	40s
Relationship	Husband	Mother	Caregiver	Wife	Wife	Caregiver

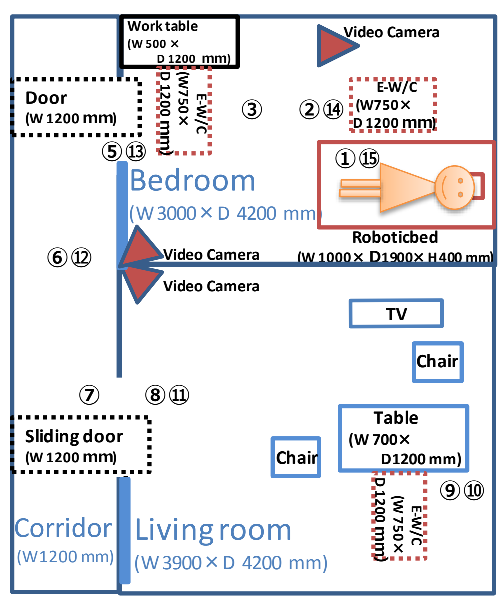

Fig. 2 Experimental setup

experienced many malfunctions during mobility. These malfunctions took place at the time of joystick operation during drive mode. Table 5 shows the number of risk situations. Risk situations during mobility were collisions with

Table 3 Support numbers for Roboticbed

Case	1	2	3	4	5	6
Transfer	21	59	55	31	39	47
Posture adjustment	9	52	43	28	35	38
Operation support	6	0	1	0	0	4
Verbal instructions	3	0	1	1	1	0
Performance support	1	0	8	0	1	0
Others	2	7	2	2	2	5
Mobility	23	13	12	15	4	6
Posture adjustment	0	6	4	4	0	1
Operation support	2	1	0	1	0	0
Verbal instructions	18	2	0	7	3	3
Performance support	3	2	8	0	0	2
Others	0	2	0	3	1	0
Total	44	72	67	46	43	53

Table 4 Malfunction numbers for Roboticbed

Case	1	2	3	4	5	6
Transfer	2	0	1	0	0	0
Mobility	26	10	9	16	26	36
Total	28	10	10	16	26	36

Table 5 Risk numbers for Roboticbed

Case	1	2	3	4	5	6
Transfer	0	0	1	3	0	0
Mobility	0	1	0	5	2	1
Total	0	1	1	8	2	1

the wall and desk accompanying a joystick operation error.

Questionnaire results

The PIADS results are shown in Fig. 3 and the QUEST results are shown in Fig. 4. The PIADS results showed that there were two groups: High PIADS score group (HP) that consists of Case1, 2 and 4 and Low PIADS score group (LP) that consists of Case3, 5 and 6. The QUEST score of participants in the HP group showed a degree of satisfaction higher. The QUEST score of participants in the LP group was lower. And, QUEST score of the LP participants were lower than that of the families or caregivers.

The subjective evaluation results for Roboticbed are shown in Tables 6, 7. Among

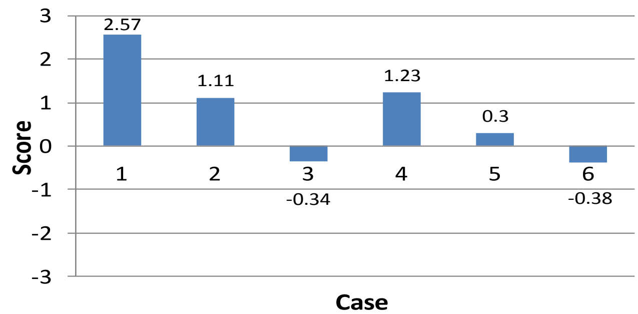

Fig. 3 PIADS score for Roboticbed

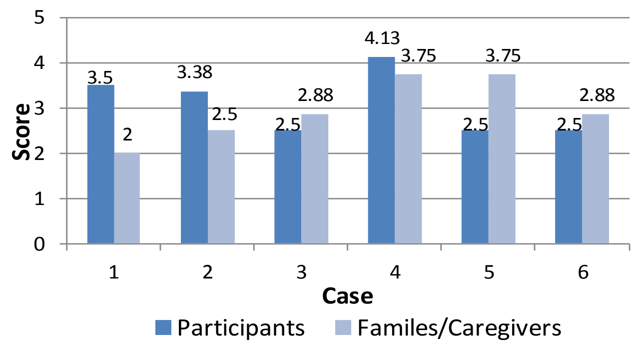

Fig. 4 QUEST score for Roboticbed

Table 6 Subjectivite evaluation of Roboticbed (participants)

Items			Case 1	2	3	4	5	6	Average
Bed	Mattress quality		8	6	3	9	3	3	5.3
	Confort		8	6	4	9	5	3	5.8
	Distortional stress	Recling posture	2	6	3	2	4	1	3.0
Transfer	Speed		5	5	6	5	5	5	5.2
	Safety		8	6	3	7	5	4	5.5
	Distortional stress	Transfer posture	5	7	5	2	5	2	4.3
Drivability	Easy		3	8	4	7	2	4	4.7
	Safety		5	7	4	7	5	3	5.2
	Speed		6	5	5	5	5	5	5.2
	Distortional stress	Activity posture	3	6	2	10	5	1	4.5
Interface	Joystick	Operate	3	7	4	7	2	1	4.0
		Position/shapes	2	8	5	10	2	0	4.3
	Remote-contoroller	Operate	2	5	4	10	4	0	4.2
		Position/shapes	3	6	4	10	4	0	4.3

(score 0=Not satisfied at all, 5=More or less satisified, 10=Very satisfied)

the participants, many had a low degree of satisfaction with the joystick operation, remote control operation, and the position and qualities of the foam padding. Moreover, in terms of distortional stress of posture during reclining or

Table 7 Subjective evaluation of Roboticbed (families/caregivers)

Items		Case 1	2	3	4	5	6	Average
Bed	Posture support	4	4	5	10	3	2	4.7
	Bed making	4	4	5	10	3	2	4.7
Transfer	Safety	5	4	9	7	9	9	7.2
	Posture support	4	4	2	5	4	3	3.7
Drivability	Safety	5	4	9	5	8	10	6.8
	Posture support	4	4	2	6	4	2	3.7
Others	Settinng of medical devices	—	—	5	10	9	4	7.0

(score 0=Not satisfied at all, 5=More or less satisfied, 10=Very satisfied)

performing an activity, the degree of satisfaction of many participants was low. Among the families or caregivers, the degree of satisfaction with posture support was low in the items: transfer, drive, and bed.

DISCUSSION

Roboticbed problems

The results showed Roboticbed needed a lot of care with respect to posture adjustment at the time of transfer and mobility. Also, in the subjective evaluations of Roboticbed, the participants experienced distortional stress during transfer and mobility, and many caregivers complained about the amount of effort required for posture adjustment. Therefore, it is seen as a problem that the position at the time of transfer and mobility is not in agreement with the body.

During mobility, many participants needed a lot of operation support for joystick operation. In addition, there were many malfunctions associated with joystick operation. In the subjective evaluation results of Roboticbed, difficulty in wheelchair propulsion and joystick operation were noted. An omni wheel is used in Roboticbed rather than a rubber-tired wheel. Therefore, it can move in all directions--front and rear, right and left, obliquely, and also turn. However, unlike a standard wheelchair, joystick operation and steering of Roboticbed during movement are difficult. And the more pronounced the handicap of the user, the harder operation becomes.

High-priority requirements for Roboticbed

The participants in the LP group were using a transferring hoist for transfer from a bed to a wheelchair. In addition, these participants used powered wheelchair indoors and outdoors for mobility. Therefore, they showed the lower PIADS score because these participants have the potential requirements to use of Roboticbed outdoors.

Furthermore, the families or caregivers in the LP group showed higher degree of satisfaction for Roboticbed than the participants. Because, we think that these families and caregivers have expectation for Roboticbed to lead of participants independence and to reduce caregiver's burden.

Validity of experiments in an experimental environment

Body posture at the time of transfer, and problems with mobility and joystick operation are problems of the highest priority. Specific problems and requirements, according to the target user's disease, characteristics, and lifestyle were also able to be identified. This study is effective in showing quantitatively during the development phase what user requirements are and what points need to be improve. These problems and requirements will become an index of clinical evaluation by users in a real-life environment.

CONCLUSION

The purpose of this study was to identify problems with Roboticbed in an experimental environment. We identified problems and high-priority requirements for Roboticbed. The results indicate that advancing clinical evaluations on the basis of real-life trials from the early development stage offer a high possibility that assistive technologies tailored to users' needs will be put into more practical use, which will lead to a better quality of life for users.

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