

ORIGINAL ARTICLE

# IMPROVED UNDERPANTS TO HELP HEMIPLEGIC STROKE PATIENTS WITH TOILETING: INVESTIGATION OF THE USEFULNESS OF UNDERPANTS WITH A CROTCH OPENABLE WITH A SINGLE ARM WHILE SITTING

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**Abstract Objectives:** We investigated the usefulness of “open-crotch underpants for single-arm manipulation” developed to facilitate toileting in stroke patients requiring help because of impaired standing balance.

**Methods:** The subjects were stroke patients allocated to two groups (independent and dependent). The study consisted of two parts. In Step 1, the degrees of crotch opening and exposure of the genital and anal area were evaluated. In Step 2, after manipulating the underpants, subjects excreted and their underpants were visually examined for soiling. In addition, subjects rated satisfaction with toileting.

**Results:** The Step-1 results showed that subjects in both groups had a significantly larger opening after the crotch-opening task than before it, suggesting that there was sufficient exposure of the genital and anal area. The Step-2 experiments revealed no soiling of underpants through excretion. Satisfaction with toileting was significantly higher with unassisted toileting using the underpants than with assisted toileting.

**Conclusion:** This study demonstrated the usefulness of these “open-crotch underpants for single-arm manipulation”, particularly for dependent hemiplegic patients.

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**Key words:** pulling the lower garments up and down; sitting position; underpants; toileting; stroke.

## Introduction

Hemiplegic stroke patients often have toileting problems that necessitate nursing care. The caregiver providing the toileting help feels physically and psychologically burdened, and the care recipient also feels emotional stress<sup>1)</sup>. Moreover, patients who need help with their toileting find it hard to live at home<sup>2)</sup>. These burdens underscore the importance of helping hemiplegic stroke patients to attain independent toileting skills, a task that involves the efforts of occupational therapists and other health care professionals<sup>3)</sup>.

Occupational therapy programs help the patient to reacquire a series of actions involving the following: 1) pulling the lower garments

up and down; 2) excretion; and 3) wiping<sup>4)</sup>. Researchers have found that the actions of pulling the lower garments up and down are the most difficult for hemiparetic patients<sup>5, 6)</sup>. Patients are generally in a standing position when they perform these actions. Therefore, standing postural instability frequently interferes with proper adjustment of the garments. Occupational therapy programs aimed at enhancing independence in performing activities of daily living (ADL) should be tailored to support patients to improve their skills in sedentary and standing activities, depending on their levels of ability<sup>7, 8)</sup>. The occupational therapist has to propose supportive measures to help hemiplegic stroke patients to properly adjust their lower garments.

Supportive means currently available for individuals with impaired standing balance include the use of procedures for pulling down the lower garments while sitting on the toilet<sup>9, 10)</sup> and the use of commercial open-crotch underpants that enable the wearer to urinate and defecate without lowering them<sup>11)</sup>. However, the procedures for pulling down the lower garments in a sitting position require highly functional capabilities that are far beyond those of most hemiplegic patients<sup>10)</sup>. Commercial open-crotch underpants, which are designed so that the crotch area opens automatically when the wearer sits on the toilet, are rarely used in clinical settings, and few studies have reported the benefits of such undergarments. The poor popularity of these underpants is attributable to the insufficient opening of the crotch area and the lack of a sense of fit, suggesting that they are not suitable for practical use<sup>12)</sup>. To address these challenges, we invented “improved open-crotch underpants.”<sup>12)</sup> These underpants were designed to enable the crotch area to be opened by pulling two strings attached at the back. One of the major disadvantages of these underpants was that one string had to be pulled from each side, causing substantial difficulties for hemiplegic patients and others with upper limb disabilities. A further improvement had to be made so that hemiplegic patients with compromised standing capability could independently complete their toileting tasks. We therefore improved our previous version and created new supportive underpants to help hemiplegic patients to expose the genital and anal area easily and sufficiently while sitting on the toilet seat. The purpose of this study was to investigate the usefulness of this improved product.

## **Overview of underpants with a crotch openable with single-arm manipulation**

The major disadvantage of our previous version (“improved open-crotch underpants”) was that it was not suited for one-arm operation<sup>12)</sup>. Taking advantage of the open-crotch mechanism and the overlapping structure of the previous version, we elongated the strings so that their termini were located on the front of the undergarment (“open-crotch underpants for single-arm manipulation,” Figures 1 and 2). With this new version, the left-hand side of the overlapping area was drawn to the left when the wearer pulled the string on the same side upward, keeping his or her left buttock slightly lifted up away from the seat. The wearer could draw the other side of the overlapping area to the right by pulling the right-hand-side string upward while lifting up his or her right buttock slightly. These procedures enabled the wearer to expose the genital and anal area and excrete without soiling the underpants while keeping them on.

## **Methods**

The study consisted of two steps. In Step 1, the “open-crotch underpants for single-arm manipulation” were tested in hemiplegic stroke patients to investigate the degrees of crotch opening and exposure of the genital and anal area. In Step 2, we asked hemiplegic patients who required toileting help to wear the trial product and to evaluate its usefulness under practical test conditions. This study was approved by The Committee of Medical Ethics of the Hirosaki University Graduate School of Medicine, Hirosaki, Japan (reference number 2012-276) and the Tokiwakai Hospital, Aomori, Japan.

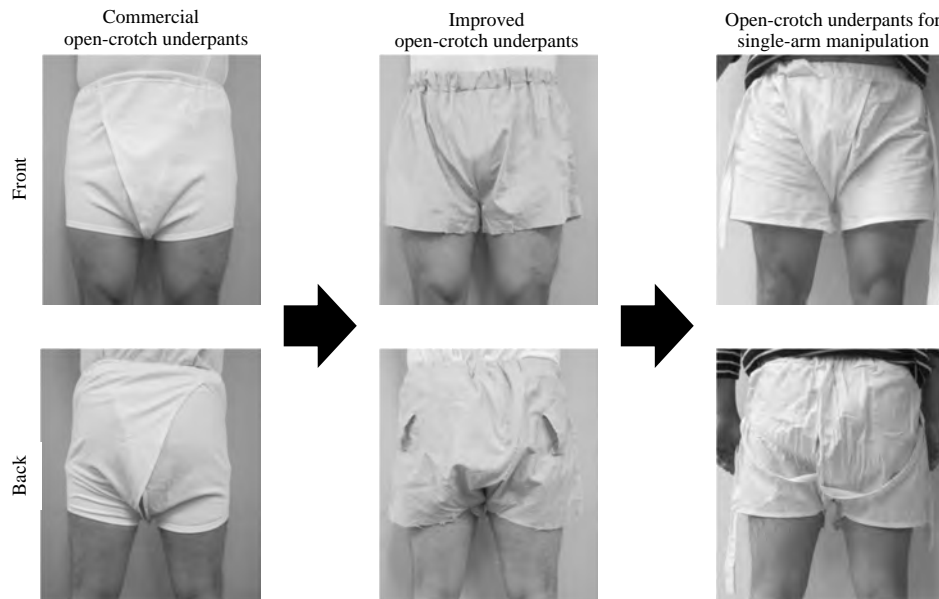


Figure 1. Changes in the structure of open-crotch underpants.

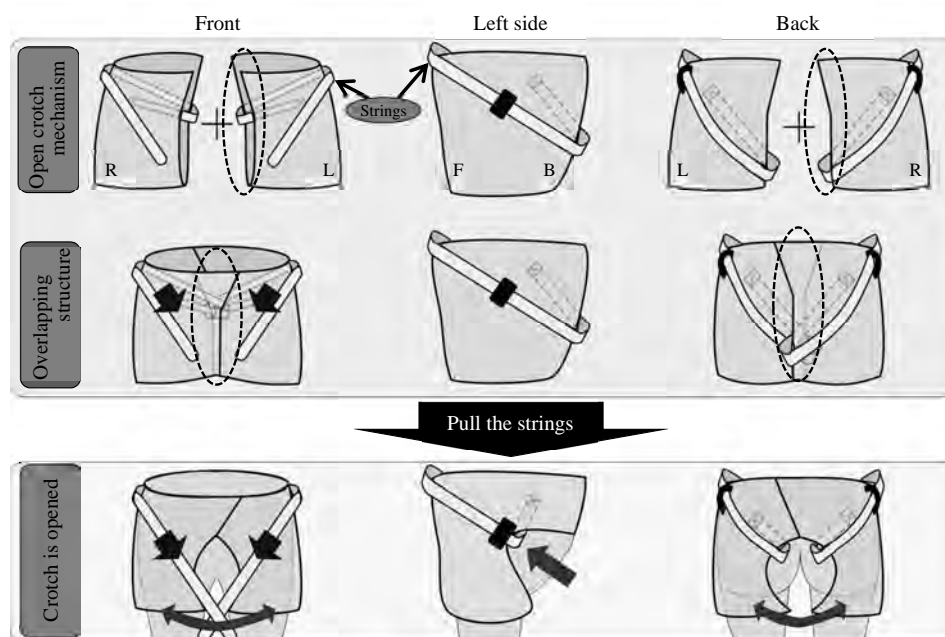


Figure 2. Structure of the "open-crotch underpants for single-arm manipulation".

## Step 1: Degrees of crotch opening and exposure of the genital and anal area

### 1. Subjects

The subjects were 11 hemiplegic stroke patients who provided informed consent for

participation in this study. Inclusion criteria included a history of cerebral hemorrhage, cerebral infarction, or subarachnoid hemorrhage. Major exclusion criteria were as follows:

- i) Multiple episodes of stroke
- ii) Unstable vital signs

- iii) Impaired consciousness, aphasia, and other language disorders that would cause difficulties in following instructions
- iv) Patients with significant communication problems because of impairment of motor and linguistic functions
- v) Patients with significant ataxia or orthopedic problems
- vi) Difficulty in maintaining sitting and standing balance without help.

## 2. Measurement parameters

### 1) Degrees of crotch opening and exposure of the genital and anal area

Subjects were asked to put on the “open-crotch underpants for single-arm manipulation” over their trousers, sit on a chair fitted a toilet seat and mirror, and keep their spine straight with their feet flat on the floor. The chair with a toilet seat and mirror was created to measure the degrees of crotch opening and genital and anal exposure from behind the subject (Figure 3). Subjects were then instructed to pull the strings with the unaffected arm to open the crotch slit. After several practice trials for familiarization with the operation, subjects made three test trials. A digital camera was used to record the images reflected in the mirror.

### 2) Subject characteristics

Data on the subjects, including age, gender, type of stroke, complications, time since stroke, side of paralysis, body weight, and locomotion, were taken from the subjects’ medical charts.

### 3) Motor paralysis

Motor paralysis of the upper and lower extremity and fingers was assessed according to the Brunnstrom motor recovery stages (Br. stage)<sup>13)</sup>.

### 4) Sensory function

The sensory functions of the upper and lower extremity and fingers were evaluated by comparing superficial sensation on the affected and unaffected sides and were divided into three



**Figure 3.** Chair with toilet seat and mirror used to measure the degrees of crotch opening and genital and anal exposure.

categories: normal, hypoaesthesia, and anaesthesia.

### 5) Muscle strength of unaffected lower extremity

Extension muscle strength of the unaffected knee was measured with a hand-held dynamometer ( $\mu$ tasF-1, Anima Corp, Tokyo, Japan). Two measurements were performed, with a sufficient amount of rest time in between. For each subject, the two results were averaged and divided by his or her body weight to characterize the muscle quality ( $\text{kg[f]}/\text{kg}$ ).

### 6) Trunk control

To evaluate trunk control, the trunk control test (TCT), a simple and validated tool examining four movements, was administered<sup>14)</sup>.

### 7) Sitting balance

To evaluate sitting balance, the functional reach test (FRT) was employed to allow us to assess dynamic sitting balance<sup>15)</sup>. The reliability and validity of the FRT have been reported by Tyson *et al.*<sup>16)</sup> Two measurements were performed, and the results were averaged for each subject to represent his or her ability.

### 8) Ability to pull the lower garments up and down during toileting

The ability to pull the lower garments up and down was assessed by using the functional independence measure (FIM) levels for toileting: 7 = complete independence, 6 = modified independence, 5 = supervision, 4 = minimal assistance, 3 = moderate assistance, 2 = maximal assistance, and 1 = total assistance<sup>4)</sup>. The original FIM scores for toileting included adjusting the

clothing before and after using the toilet as well as maintaining perineal hygiene. For this study we modified the criteria and eliminated perineal cleanliness.

### 3. Analysis

Digital photographic images were processed by using image processing software (Adobe Photoshop CS6 Extended, Adobe Systems Japan, Tokyo, Japan) to determine the area of crotch opening and the inner area of the toilet seat. These measurements were then used to calculate the percentage crotch opening by dividing the former area by the latter. The median values of three measurements of percentage crotch opening before and after the crotch-opening task were used for analysis. Crotch-opening performance and degrees of genital and anal exposure were compared between before and after the string-pulling operation. To evaluate the utility of the new underpants, subjects were allocated to 2 groups: those who could do this task independently (the “independent group”) and those who could not (the “dependent group”). Subjects with FIM toileting scores of 6 and 7 were categorized as independent, whereas those with FIM toileting scores of 5 or less were dependent. Independent and dependent subjects were also compared with regard to their general characteristics and the degree of genital and anal exposure.

The Wilcoxon signed rank test was used to compare the degree of crotch opening between before and after the string-pulling operation. The Mann-Whitney U-test was used to detect differences in crotch opening performance between independent and dependent subjects. In addition, to identify possible differences in subject characteristics between the independent and dependent groups, we used the Mann-Whitney U-test to compare age, time since stroke, strength of muscle extension in the unaffected knee, sitting FRT, total TCT score,

and TCT subscale score. The chi-squared test was used to compare the between-group distributions of gender, type of stroke, complications, side of paralysis, Br. stage, sensory function, and locomotion. Statistical analyses were performed with IBM SPSS Statistics for Windows Version 17.0 (IBM SPSS Japan, Tokyo, Japan), and the significance level was set at  $P < 5\%$ .

## Step 2: Evaluation of practical utility

### 1. Subjects

Step 2 involved five consenting subjects who required toileting help. Three of them were Step-1 subjects, and two were newly recruited. They were chosen on the basis of the key inclusion criterion, namely a modified FIM score for toileting (explained in Step 1) of 5 or less.

### 2. Measurement parameters

After putting on the “open-crotch underpants for single-arm manipulation” and pulling the strings, subjects were instructed to excrete while sitting on the toilet seat. Following this, the items listed below were investigated to evaluate the usefulness of the “open-crotch underpants for single-arm manipulation.”

#### 1) Underpants soiling

After subjects had performed their excretions, their underpants were visually examined for soiling.

#### 2) Impressions on fit and usability

Subjects were asked to rate their impressions on wearing and using the study product on a 100-mm visual analog scale (VAS), with endpoints ranging from “Very good (0 mm)” to “Very bad (100 mm).”

#### 3) Patient satisfaction with toileting

Subjects’ degrees of satisfaction were compared between assisted toileting and unassisted toileting using the “open-crotch underpants for single-arm manipulation.” Subjects were asked



to record VAS scores, with endpoints ranging from “Very unsatisfied (0 mm)” to “Very satisfied (100 mm).”

### 3. Analytical methods

The results were tabulated for comparison. Differences in patient satisfaction between assisted and unassisted toileting tasks were evaluated by using the Wilcoxon signed rank test. Statistical analyses were performed with IBM SPSS Statistics for Windows Version 17.0 (IBM SPSS Japan), and the significance level was set at  $P < 5\%$ .

## Results

### Step 1: Degrees of crotch opening and exposure of the genital and anal area

Table 1 compares the characteristics of subjects in the independent and dependent groups. Compared with independent subjects, dependent subjects had significantly lower total TCT scores and lower scores on the following TCT subscales: rolling to weak side, rolling to strong side; and sitting up from a lying position ( $P < 0.05$  for all). The proportion using wheelchairs was significantly higher in dependent subjects ( $P < 0.05$ ), and significant differences were noted between groups in terms of gender and side affected by the stroke ( $P < 0.01$  for both). However, balance in the sitting position (a TCT subscale), Br. stage, sensory function, knee extension muscle strength on the unaffected side, and sitting FRT did not differ significantly between groups.

Table 2 shows the results for crotch opening in the independent and dependent subjects. For both groups, the area of the crotch opening was significantly greater after the string-pulling manipulation than before it ( $P < 0.05$ ). Comparison of the two groups showed no significant difference in the percentage crotch opening.

We then compared the exposure of the genital and anal area between the independent and dependent groups (Figure 4). No genital or anal exposure was observed in either group before the string-pulling operation. The genital and anal area was sufficiently exposed after the operation in both groups.

### Step2: Evaluation of practical utility

No subjects soiled their underpants upon excretion after single-arm operation. The median VAS score for wearing impression was 73.0(56.0-87.0) %, suggesting that a majority of subjects felt comfortable with the product. The median VAS score for use impression was 55.0 (55.0-76.0) %. Subjects were significantly more satisfied with unaided toileting tasks involving the use of the “open-crotch underpants for single-arm manipulation” than with assisted toileting ( $P < 0.05$ ) (Table 3). However, in many cases the crotch slit did not completely return to its original state after it had been opened wide once.

## Discussion

### 1. Advantages of “open-crotch underpants for single-arm manipulation”

This study demonstrated that our new trial product helped hemiplegic patients to complete their toileting independently. The percentage crotch opening was no significant difference between the independent and dependent groups. The dependent subjects opened up the crotch area of the underpants with one arm while they sat on the toilet seat and managed to excrete without soiling the underpants. Our new product also significantly enhanced patient satisfaction with toileting; it helped hemiplegic patients to develop a sense of achievement for having completed their toileting independently, because their impaired ability to maintain standing balance had led them to require

**Table 1.** Comparison of characteristics of patients in the independent and dependent groups

	Independent group (n = 5)	Dependent group (n = 6)	P-value
Age (years) <sup>†</sup>	65.0(62.0–68.0)	80.0(77.5–81.8)	0.082
Gender <sup>††</sup> : male / female	5 / 0	1 / 5	0.006**
Type of stroke <sup>††</sup> : infarction / hemorrhage / subarachnoid hemorrhage	1 / 4 / 0	4 / 2 / 0	0.122
Complications <sup>††</sup> : HT / DM / HL / other	4 / 1 / 0 / 1	4 / 1 / 1 / 0	0.572
Time since stroke (months) <sup>†</sup>	20.0(15.0–61.0)	114.5(69.0–129.3)	0.144
Side of paralysis <sup>††</sup> : right / left	5 / 0	1 / 5	0.006**
Br. stage			
Upper extremity <sup>††</sup> : I / II / III / IV / V / VI	0 / 2 / 2 / 0 / 0 / 1	0 / 5 / 0 / 1 / 0 / 0	0.155
Fingers <sup>††</sup> : I / II / III / IV / V / VI	2 / 2 / 0 / 0 / 0 / 1	4 / 0 / 0 / 2 / 0 / 0	0.132
Lower extremity <sup>††</sup> : I / II / III / IV / V / VI	0 / 0 / 2 / 2 / 0 / 1	0 / 1 / 5 / 0 / 0 / 0	0.155
Sensory function			
Upper extremity <sup>††</sup> : normal / hypoesthesia / anesthesia	1 / 4 / 0	2 / 3 / 1	0.497
Fingers <sup>††</sup> : normal / hypoesthesia / anesthesia	1 / 4 / 0	2 / 3 / 1	0.497
Lower extremity <sup>††</sup> : normal / hypoesthesia / anesthesia	2 / 3 / 0	2 / 3 / 1	0.632
Knee extension muscle strength on unaffected side (kgf/kg) <sup>†</sup>	0.26(0.23–0.32)	0.23(0.16–0.33)	0.462
Total TCT score <sup>†</sup>	100.0(74.0–100.0)	49.0(49.0–58.0)	0.015*
1. Rolling to weak side <sup>†</sup>	25.0(12.0–25.0)	6.0(0.0–12.0)	0.019*
2. Rolling to strong side <sup>†</sup>	25.0(25.0–25.0)	12.0(12.0–12.0)	0.044*
3. Balance in sitting position <sup>†</sup>	25.0(25.0–25.0)	25.0(25.0–25.0)	1.000
4. Sitting up from a lying position <sup>†</sup>	25.0(12.0–25.0)	12.0(3.0–12.0)	0.026*
Sitting FRT (cm) <sup>†</sup>	26.0(23.0–37.0)	24.5(21.5–26.8)	0.463
Locomotion <sup>††</sup> : cane walking / wheelchair	3 / 2	0 / 6	0.026*

Values are medians (25%–75%).

HT: hypertension; DM: diabetes mellitus; HL: hyperlipidemia; Br. stage: Brunnstrom stage; FRT: functional reach test; TCT: trunk control test.

<sup>†</sup>: Mann-Whitney U-test; <sup>††</sup> chi-squared test; \*:  $P < 0.05$ , \*\*:  $P < 0.01$ .

**Table 2.** Comparison of percentage crotch openings between before and after the crotch-opening task in the independent and dependent groups

	Independent group (n = 5)	Dependent group (n = 6)
Before crotch-opening task (%)	0.0 (0.0–0.0)	0.0 (0.0–0.0)
After crotch-opening task (%)	64.8 (54.8–72.8)*	59.1 (56.6–60.8)*

Values are medians (25%–75%).

Wilcoxon's signed rank test was used to compare the percentage crotch openings before and after the crotch-opening task: \*  $P < 0.05$ .

The Mann-Whitney U-test was used to compare the percentage crotch opening between the independent and dependent groups.

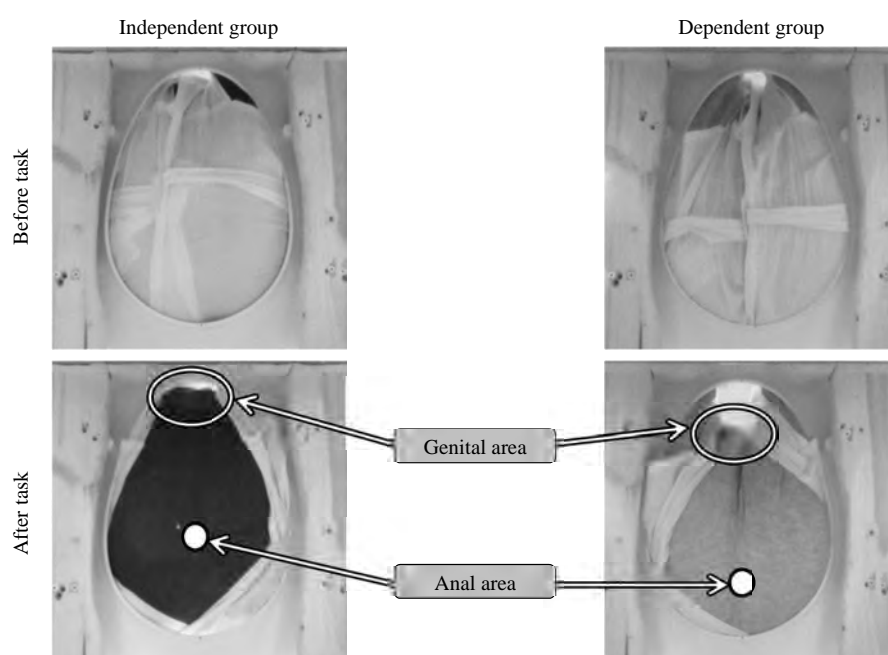
Comparison of the independent and dependent groups showed no significant difference in the percentage crotch opening.

toileting help. Our findings suggested that the new underpants were effective for helping dependent subjects.

## 2. Disadvantages of “open-crotch underpants for single-arm manipulation”

A major disadvantage of the new underpants

is that the crotch slit did not completely return to the original closed position after opening. The underpants we used were geared toward hemiplegic patients who required toileting help because of impaired standing balance. They were designed such that the crotch slit would spontaneously close when the wearer stood up.



**Figure 4.** Comparison of genital and anal exposure using “open-crotch underpants for single-arm manipulation” in the independent and dependent groups

**Table 3.** Satisfaction with toileting

	Dependent group (n = 5)	
	Assisted toileting (before using “open-crotch underpants for single-arm manipulation”)	Unassisted toileting (after using “open-crotch underpants for single-arm manipulation”)
Satisfaction with toileting (%)	48.0 (44.0-58.0)	64.0 (56.0-76.0)*

Values are medians (25%–75%).

Wilcoxon’s signed rank test, \* $P < 0.05$ .

However, the standing action of the wearer did not provide sufficient mechanical force to make the opened slit return to its original position. The observed insufficient closure could be attributable to friction between the strings and the surface of the underpants or to other design-related matters. Further efforts should be made to improve the utility of these underpants.

### 3. Applicability of “open-crotch underpants for single-arm manipulation”

As explained earlier, studies have suggested that patients receiving toileting help place a strong emotional burden on their caregivers<sup>1)</sup>

and that the use of absorbent products could accelerate the onset of dementia<sup>17)</sup>. In hemiplegic patients, impaired standing balance often causes problems with independent toileting. However, hemiplegic patients who are unable to pull their lower garments up and down independently have retained their sitting balance<sup>18)</sup>. Therefore, the development of underpants that hemiplegic patients can manipulate while sitting on the toilet seat will reduce their psychological stress while also slowing the progression of dementia. These toileting aids should help promote independence in toileting and improve quality of life<sup>19)</sup>. We found here that “open-crotch



underpants for single-arm manipulation” helped hemiplegic patients to successfully complete their toileting independently. In addition, we identified a major challenge to improving the underpants to enable the crotch slit to return to its initial position after opening.

#### 4. Conclusion

We developed and investigated the usefulness of open-crotch underpants with a crotch that could be opened by single-arm operation. The “open-crotch underpants for single-arm manipulation” were designed to help hemiplegic patients requiring toileting care to complete their toileting tasks independently. Hemiplegic patients, while seated on the toilet, successfully opened the crotch to expose the genital and anal area and completed their tasks without soiling their underpants. Our study thus demonstrated the usefulness of these underpants. One major disadvantage was that the crotch slit did not return completely to its original position after opening, warranting further efforts for improvement.

#### Acknowledgments

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