1. Introduction

Pinch hangers, bath towel racks, and clothes hangers are often used for hanging washed pullovers to dry. Hanging clothes with one hand is not easy, irrespective of the tools used [1]. This particularly poses a challenge to patients with orthopedic diseases and hemiplegia, as they are forced to use the unilateral upper extremity owing to various reasons. Among the abovementioned tools, clothes hangers are best suited for hanging pullover garments considering the appearance of dried garments. However, hanging a washed pullover garment on a clothes hanger is a task that is usually considered to be extremely difficult to accomplish without the use of both hands because one hand inserts the hanger inside the garment, and the other adjusts the garment’s position on the hanger. One method for hanging front-opening garments with one hand requires one to first hang the garment on a chair’s backrest, insert the hanger into the garment by using the opening in front of the garment,
and finally pull the hanger’s hook upward along with the garment [2]. However, this method is inconvenient for hanging pullover garments. We hypothesized that a clothes hanger hooked onto the backrest of a chair (backrest hanger) would facilitate better hanging for pullover garments that need to be dried with one hand; in particular, one can place a pullover garment on a backrest hanger and then pull the hanger along with the garment upward in order to separate them from the backrest.

This study aimed to demonstrate the usefulness of a backrest hanger for one-handed clothes hanging by observing healthy volunteers and patients with hemiplegia who used only one hand to attempt to hang a pullover garment on a backrest hanger, a pinch hanger, and a bath towel rack; after this the results for each tool were compared.

2. Methods

Participants

The study included 20 healthy volunteers (11 women; \(M_{\text{age}} = 21 \pm 2\) years; range = 18–31 years), and 16 patients with hemiplegia due to cerebral infarction or hemorrhage (10 women; \(M_{\text{age}} = 64 \pm 13\) years; range = 44–85 years). The median intelligence of both groups was scored using the Hasegawa Dementia Rating Scale-Revised [3]. The score for the healthy sample was 30/30 points (range = 29–30 points), while, for the hemiplegic patients, it was 26/30 points (range = 24–29 points). All patients were in the chronic phase and regularly visited the daycare facilities.

This study was conducted in accordance with the Declaration of Helsinki after approval from the Institutional Review Board of Tohoku Medical College (approval number, 411). All participants provided written consent after receiving a detailed explanation of the study.

Equipment

The participants performed tasks while sitting in a chair in order to prevent themselves from falling [4]. Participants were requested to hang a washed pullover garment with one hand using a backrest hanger, pinch hanger, and bath towel rack as shown in Fig. 1. The pullover garment used in this task was a sweatshirt (dry weight, about 430 g) that was washed and dewatered for 7 minutes (weight after dewatering, about 620 g). The sweatshirt was placed in a basket within the reach of the participant. A backrest hanger was prepared by hanging a clothes hanger over a chair backrest via a wire hook attached to the backrest, as indicated by the arrow in Fig. 1. A pinch hanger was used by hanging it on a laundry pole.

Participants hanging the pullover garment to dry were recorded at 30 frames per second using two digital video cameras (NV-GS300; Panasonic Inc, Osaka). The camera was set at lateral side from the side of the hand used for the task and another camera was set diagonally behind on the opposite side. Images from these two video cameras were recorded synchronously and analyzed with a digital motion picture waveforms real-time synchronous recording system (The Teraview, Gigatex CO., Ltd.) for analysis.

Procedure

Healthy participants were included in Experiment 1, while patients with hemiplegia were included in Experiment 2.

Experiment 1. Participants were requested to hang a sweatshirt to dry in any way using only their non-dominant hand and three tools mentioned above. Their
order was counterbalanced, and the experiment was conducted after the participants had practiced to satisfaction. After completing the task with all the three tools, the participants were asked to subjectively rate how easily the sweatshirt was hung to dry with respective tools. Furthermore, after the sweatshirt had dried, the participants were asked if they would wear it as is and go out.

Subsequently, we reviewed video images of all healthy participants and measured the total time required to hang a sweatshirt with each of the tools (hereinafter referred to as “hanging operation time”). In addition, we selected the method of hanging adopted by the largest number of participants for each tool, summarized the key points, and used them for the participants of Experiment 2. We instructed how to hang a sweatshirt to the patients depends on the results of Experiment 1, since those patients have never washed cloth after stroke.

The sweatshirts were hung to dry indoors synchronously with respective tools, as explained to patients with hemiplegia in Experiment 2, and lengths of time required for drying (hereinafter referred to as “drying time”) were measured. When the bath towel rack was used, however, one side of the sweatshirt was dried, and then turned over for the other side to dry, as the sweatshirt was held in half.

**Experiment 2.** Patients with hemiplegia were requested to hang a sweatshirt to dry with their non-paralytic, using the three tools mentioned above. An examiner provided instructions regarding the hanging process for each tool, and patients performed the task after practicing to satisfaction. The three tools were again counterbalanced, and the participants were asked to subjectively rate their ease in hanging the sweatshirt to dry, and whether they would wear it as is and go out. Further, the time taken to hang the sweatshirt was measured for each of the tools.

**Analysis**

Overall, four aspects were analyzed:

**Subjective assessment of ease of hanging.** The participants rated the tasks as “very easy,” “somewhat easy,” “neither easy nor difficult,” “somewhat difficult,” or “very difficult”. Total responses for each of the options were counted.

**Finish and acceptability of sweatshirts to be worn outside.** Drying was considered done when the weight of the sweatshirt became equal to its dry weight measured before washing. In addition, the participants were asked if they felt comfortable wearing those sweatshirts outside, and the yes/no responses were counted.

**Hanging operation time.** The duration required to complete the hanging task (from removing the sweatshirt from the basket to taking the hand off of the hung sweatshirt) was measured using video images. The total hanging operation time for all three tools was compared using the Friedman test both in the Experiment 1 and 2. If differences were observed, data with the 3 tools were subjected to 2-group comparisons by Wilcoxon’s signed rank test, and the significance level was < 1.6% after Bonferroni correction. In Experiment 2, any patient who could not use a tool was excluded from comparison.

Furthermore, the hanging operation time for healthy participants and those with hemiplegia was compared for each tool. Mann-Whitney U test was used to test differences, and the significance level was < 5%.

**Drying time.** The duration from when a dewatered sweatshirt was hung until when the sweatshirt was considered dry was measured. A hung sweatshirt was considered dry when its weight became equal to its dry weight measured before washing.

### 3. Results

**Experiment 1 (Healthy Volunteers)**

**Subjective assessment of ease of hanging.** The backrest hanger was rated as the easiest tool to use (Table 1).

**Finish and acceptability of sweatshirts to be worn outside.** The sweatshirts hung to dry with backrest hangers had nearly intact shape (Fig. 2, left). Those hung to dry with pinch hangers had marks and were stretched where clothespins were placed (Fig. 2 middle, circled). Those dried using bath towel racks had a mark of the bar where folded (Fig. 2 right, arrow). Sweatshirts dried using backrest hangers were deemed comfortable to wear and go out by the majority of participants (Table 1A).

**Hanging operation time.** The median (interquartile range) of hanging operation time were 18.1 (14.8–20.2) sec, 57.0 (38.4–79.7) sec, and 35.7 (26.6–39.5) sec, respectively (Table 1A). Shortest duration was required to complete the hanging task using the backrest hanger, followed by the bath towel rack, and then the pinch hanger (p < .01).

**The most commonly used way of hanging.** Figure 3 displays the most commonly used way of hanging backrest hangers (a), pinch hangers (b), and bath towel racks (c). The methods shown in the figure were used by 12, 20, and 7 participants, respectively. The most commonly used way of hanging sweatshirt using a backrest hanger was as follows: The arm is inserted into the neck hole of the sweatshirt to reach the hem and the sweatshirt is lifted; then the hanging side of the hem is placed on the backrest to start covering the side ipsilateral to the arm being used; while retaining the arm in the sweatshirt, the arm is moved on the backrest.
Table 1. The responses of healthy volunteers and patients with hemiplegia to different tools.

|                                | Backrest hanger | Pinch hanger | Bath towel rack | P value* |
|--------------------------------|-----------------|--------------|-----------------|----------|
| **A. Experiment 1 (healthy volunteers)** |                 |              |                 |          |
| **Assessment of ease of hanging (number of subjects)** |                 |              |                 |          |
| Very easy                      | 14              | 0            | 7               |          |
| Somewhat easy                  | 6               | 0            | 7               |          |
| Neither easy nor difficult     | 0               | 1            | 6               |          |
| Somewhat difficult             | 0               | 2            | 0               |          |
| Very difficult                 | 0               | 17           | 0               |          |
| **Clothes were comfortable to wear and go out in?** |                 |              |                 |          |
| Yes                            | 20              | 0            | 12              |          |
| No                             | 0               | 20           | 8               |          |
| I do not know                  | 0               | 0            | 0               |          |
| **Hanging operation time (seconds)** |                 |              |                 |          |
| Overall subject population     | 18.1 (14.8–20.2) | 57.0 (38.4–79.7) | 35.7 (26.6–39.5) | < 0.01* |
| Subjects who hung the tool to dry according to the instructions provided to the patients with hemiplegia | 16.9 (14.5–19.2) | 57.0 (38.4–79.7) | 32.4 (25.2–38.4) |          |
| **Drying time (hours)**        | 8               | 8            | 12              |          |
| **B. Experiment 2 (patients with hemiplegia)** |                 |              |                 |          |
| **Assessment of ease of hanging (number of subjects)** |                 |              |                 |          |
| Very easy                      | 13              | 0            | 0               |          |
| Somewhat easy                  | 3               | 0            | 11              |          |
| Neither easy nor difficult     | 0               | 0            | 5               |          |
| Somewhat difficult             | 0               | 0            | 0               |          |
| Very difficult                 | 0               | 16           | 0               |          |
| **Clothes were comfortable to wear and go out in?** |                 |              |                 |          |
| Yes                            | 2               | 0            | 0               |          |
| No                             | 0               | 2            | 2               |          |
| I do not know                  | 14              | 14           | 14              |          |
| **Number of subjects who completed the hanging task** | 16              | 12           | 16              |          |
| **Hanging operation time (seconds)** | 16.9 (15.1–28.6) | 48.4 (34.0–62.3) | 28.7 (19.5–54.3) | < 0.01* |

The hanging operation time lengths for all healthy volunteers are shown in mean form (standard deviation). The hanging operation time lengths for healthy volunteers who hung a sweatshirt to dry according to the instructions provided to the patients with hemiplegia and the hanging operation time lengths for patients with hemiplegia are shown in median form (interquartile range).

* Wilcoxon’s signed rank test ($p < .016$): Backrest hanger < Pinch hanger, Bath towel rack < Pinch hanger, Backrest hanger < Bath towel rack

Fig. 2. Appearance of dried sweatshirts.

Sweatshirts dried using a backrest hanger (left), pinch hanger (center), and bath towel rack (right). Circles in the center panel indicate hem areas of the pinch hanger-dried sweatshirt where clothespin marks and stretches were observed. The arrow in the right panel denotes the mark of a rod of the bath towel rack.
first horizontally to the other side, then downward so that the sweatshirt covers the entire backrest, including the opposite surface; then the hanger is pulled up to detach it with the sweatshirt from the backrest; and this completes the hanging operation with a backrest hanger. Operations with other tools are shown in lower tiers in the figure. Patients with hemiplegia were instructed to use these ways of hanging in Experiment 2.

**Drying time.** The total drying time when using backrest hangers was comparable with that of pinch hangers, and 30% shorter than that of bath towel racks (Table 1A).

**Experiment 2 (Patients with Hemiplegia)**

**Subjective assessment of ease of hanging.** The backrest hanger was rated as the easiest tool to use.

**Finish and acceptability of sweatshirts to be worn outside.** Finished sweatshirts after drying were characterized similarly as in Experiment 1. Fourteen patients said, “I do not know because I do not usually wear sweatshirts.” The remaining two patients answered OK for the backrest hanger, but not OK for other tools.

**Hanging operation time.** Four patients could not complete the hanging task using a pinch hanger. The median (interquartile range) of hanging operation time were 16.9 (15.1–28.6) sec, 48.4 (34.0–62.3) sec, and 28.7 (19.5–54.3) sec, respectively (Table 1B).
duration required to complete the hanging task using a backrest hanger was significantly shorter than that required using either of other two tools \( (p < .01) \). In addition, there were no significant differences in hanging operation time between patients with hemiplegia and healthy participants who used the same ways of hanging for respective tools.

4. Discussion

Results from these experiments demonstrated that, among the three tools, the backrest hanger was the easiest and quickest one to hang a sweatshirt to dry for healthy volunteers. They reported that they would be comfortable going out wearing the sweatshirts dried using backrest hangers. The backrest hanger was the easiest tool to hang a sweatshirt to dry also for patients with hemiplegia. When pinch hangers were used, four patients could not complete the hanging task, indicating that the pinch hanger may not always be suitable for patients with hemiplegia. Moreover, even in the comparison that excluded these patients, the backrest hanger had the shortest drying operation time among the three tools. These findings suggest that backrest hangers are more practically useful to hang pullover garments to dry than pinch hangers or bath towel racks for both healthy individuals and patients with hemiplegia.

When using a pinch hanger, the participants had to correct its position during the task (Fig. 3b). With respect to the bath towel rack, participants had to horizontally pull both sides of the sweatshirt hung on a rod several times to prevent wrinkle formation (Fig. 3c). The backrest hanger did not require any of these actions. Relatively simple series of actions were required to cover the backrest with a pullover garment, so the participants did not fail often. This is presumably why the backrest hanger was considered easy to use and required a shorter duration to complete the hanging task. For pinch hangers, several methods to solve difficulties in the hanging operation were reported, including a method of placing a pinch hanger on the table then starting the hanging operation [5], the use of a pinch hanger designed for one-hand users [6], and a method of attaching a curtain hook to each clothespin, putting such clothespins on a garment on the table, and hanging the garment over a pinch hanger through the curtain hooks [7]. However, irrespective of the methods used, the dried garment had marks and stretched where a clothespin was put, as shown in the center of Fig. 2. Consequently, we consider the use of a backrest hanger to be favorable than any of the previously reported methods.

As a pullover garment, we did not use a sweater or undershirt that is often worn by individuals in the age group of hemiplegic patients in this study. In addition, we did not directly ask with which method the finished garments were most preferable. As a result, we were uncertain about how the patients with hemiplegia felt regarding the finish with different tools. Nevertheless, sweaters and undershirts hung to dry using respective tools are expected to have similar characteristics to those seen in this study. The use of backrest hangers is likely to be most preferred as it does not leave any pinch mark, stretch, or folding line.

No significant differences were observed between healthy participants and patients with hemiplegia in terms of the time required to complete the hanging task for all the tools. In other words, patients with hemiplegia could complete the task in the same amount of time as the healthy participants albeit the backrest hanger method being new to them.

Limitations and Future Directions

In this study, participants with hemiplegia were limited to chronic-phase patients capable of attending a daycare service facility. In addition, patients with severe higher brain dysfunction were not included. Therefore, it remains unclear whether the backrest hanger method has a similar level of usefulness in acute-phase patients or patients with severe higher brain dysfunction. For example, the method may be difficult for patients with amnesia because they have to remember how to use the backrest and hanger they have never used before. It is conceivable that the method is similarly effective in patients who are forced to use the unilateral upper limb due to orthopedic diseases; however, this has not been demonstrated. In the future, the practical usefulness of this method should be tested in other patient populations, such as acute-phase patients, patients with higher brain dysfunction, and patients with orthopedic diseases.

In the present study, we studied one part of the whole process of washing clothes. Thus, in the future study, it should be important to focus on the whole process of washing clothes as daily activity.

5. Summary and Conclusions

We requested healthy volunteers and patients with hemiplegia to hang a sweatshirt to dry by using only one hand to operate three tools: a backrest hanger, a pinch hanger, and a bath towel rack. Next, the participants were requested to rate their level of ease in hanging the sweatshirts, and the time they took to complete the task was measured. Both healthy volunteers and patients with hemiplegia reported that the backrest hanger was the easiest tool to use for hanging sweatshirts, and it required a significantly shorter amount of time compared
to the other two tools. The study findings thus indicated
the high practical usefulness of the backrest hanger
method.

Conflict of Interest

There are no conflicts of interest to declare.

Acknowledgments

We are grateful to Keiko Endo for her constant
support and insightful comments.

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