An Assessment of Workload
When Putting on / Removing Nursing Care Upper wear

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Abstract: In this research, the movements of caregivers when putting on / removing a dummy's nursing care upper wear with different designs were measured using electromyography (EMG) and captured on video. Two nursing care upper wear samples were used. Sample1 was a upper wear with raglan sleeves, which is commonly used. Sample2 was a upper wear with a fastener on each arm. Subjects were 9 healthy men aged 22 ± 2 years, with a height of 170 ± 8cm and weight of 58 ± 9 kg. None of the men had previously provided nursing care. The subjects were put on and removed the upper wear on the dummy (height 150cm, weight 12kg) which was sitting on a bed. EMG measured the subject’s upper limbs, waist and legs. When the task finished, subjects filled out a questionnaire about the sensation of working and burden. Images of the task were recorded using a digital camera. The results showed Sample2 performed well concerning working and burden when removing the upper wear. The proportion EMG of Sample2 to voluntary movements of the upper limbs was low. The design of nursing care wear needs to fit the capabilities (such as paralysis) of the nursing care recipients. It is argued that by taking such an approach, nursing care clothes may be developed that would further reduce the burden on caregivers while providing nursing care.

Key words: Nursing Care Upper wear, Workload, EMG, Work Time

1. Introduction
In Japan, the percentage of elderly persons aged 65 or older exceeded 21% of the total population in 2007[1]. Now that a super-aging society is here to stay in this country, nursing care has become a significant social issue. When preparing for the national exams to gain a license, nursing care workers study to acquire basic job techniques, ergonomic knowledge, and body mechanics skills that will help them to ease the workload of nursing care[2,3]; however, it is too much to ask members of the general public, who often provide home-based care for their family members, to acquire such basic techniques and expert knowledge[4,5,6]. Such being the case, there has been growing demand for the development of nursing care goods that ordinary people can use effectively in their own homes without a great deal of expert techniques or knowledge[7].

In this research, movements of caregivers when putting on / removing a dummy’s nursing care clothing with different designs were measured using electromyography (EMG) and video filming. Caregivers’ sensory assessments of the workload generated by their services were also investigated to determine how the physiological burden and sensation of burden relate to each other. More specifically, the burden on caregivers was not only
assessed using motion analysis and EMG analysis, but their sensation of burden was also taken into account with a view toward gaining knowledge useful for designing caregiver-friendly nursing care goods that will help to reduce their burden.

2. Methodology

2.1 Subjects and experiment samples

The subjects were 9 healthy male students that had no previous experience in providing nursing care. Two kinds of samples were used for this experiment. Sample 1 consisted of an ordinary pajama-type nursing care top (Figure 1 right) and Sample 2 consisted of a nursing care top with fasteners (YKK, total length: 48 cm) stretching from the shoulders to the sleeve cuffs (Figure 1 left). Both samples had raglan sleeves and five resin buttons (14 mm in diameter) on the front.

![Figure 1 Experiment samples (left: Sample 1, right: Sample 2)](image)

2.2 Experiment procedures and measurement parameters

For this experiment, a silicon dummy nicknamed "Koharu-san" (Mitaka Supply Co., Ltd.; Height: 150 cm, Weight: 12 kg) was placed on the bed in a sitting position. Subjects were asked to put on / remove the two types of nursing care tops as they stood facing the left side of the dummy. These experiment procedures were performed with the dummy in two different positions. The position for the first experiment procedure assumed a nursing care recipient capable of moving his or her upper limbs freely (Figure 2 left), while that for the second experiment procedure assumed a nursing care recipient with his or her right upper limb crooked with paralysis and thus unable to move (Figure 2 right). To put on the clothing, the subjects were asked to put the sample that spread behind the dummy and fasten the buttons. To remove the clothing, the subjects were asked to remove the sample that the dummy was wearing. After rehearsals, each subject was asked to follow the procedure of putting on / removing the clothing twice for each of the two samples (a total of eight procedures). The bed was 90 cm long, 180 cm wide, and 70 cm tall.
EMG measurements were taken to assess the physiological burden during the procedures based on the amount of muscle activity. Electrodes were attached at a total of eight points: the left and right biceps brachii muscles, palmaris longus muscles, erector spinae muscles, and biceps femoris muscles. To analyze the procedures in detail, the experiment process was recorded on video using a digital camera (Pentax Optio T30) from the right side of the dummy (Figure 3). In order to assess the sensation of fatigue duty – a type of physiological workload – the subjects were asked to rate two parameters of ease and burden of the procedures in five grades (-2 to +2 pts.) after the experiment. The subjects were also asked to rate their sensation of burden according to five grades from 0 to 4 points at five regions: the whole body, forearms, upper arms, waist, and thighs. For EMG measurements, Nihon Kohden Corporation's multi-channel telemeter system WEB-1000 was used and measurement data were recorded on a notebook PC at a sampling frequency of 1 kHz.

2.3 Analysis methods

In order to assess the physiological burden on the subjects, the root mean square (RMS) of the muscles being experimented on during the procedures were calculated, and were then standardized using the maximum voluntary contraction (VC) value of voluntary movement as a reference to calculate a muscular activity ratio per unit time (see the equation below). For voluntary movement, the subjects were asked to contract each muscle being experimented on with maximum force. Specifically, VC was measured while the subjects bent their elbow joints (biceps brachii muscles), clenched their fists (Palmaris longus muscles), and dorsiflexed their erector spinae muscles and biceps femoris muscles with their buttocks protruding out and back.
In the video analysis, time for putting on and removing clothing was measured using the recorded footage. The work process was divided into two parts and the times for each sub-process were compared: procedures around the arms (Process 1) and procedures around the buttons (Process 2).

To assess the psychological workload, i.e. the sensations of fatigue duty and burden, statistical analysis was conducted on scores from the seven items of the SD method sensory tests.

3. Results

3.1 Muscular activity during the procedures

Figures 4, 5, and 6 show the results of EMG analysis. In those figures, Muscles 1 and 2 are the biceps brachii muscles, Muscles 3 and 4 are the Palmaris longus muscles, Muscles 5 and 6 are the erector spinae muscles, and Muscles 7 and 8 are the biceps femoris muscles. Odd-numbered muscles are on the right side of the body, while even-numbered ones are on the left side of the body. The figures show that values for the erector spinae muscles (Muscles 5 and 6) are greater than those of other muscles, which is attributable to the fact that their standard voluntary contraction was relatively small. Accordingly, the amount of muscle activity is compared among different samples below, rather than among the different muscles being experimented on.

During the procedure of putting on the clothing (Figure 4), a significant difference (p < 0.05) was observed for the left biceps brachii muscle (Muscle 2) in Procedure 1 and for the right biceps femoris muscle (Muscle 7) in Procedure 2. Similarly, during the procedure of removing the clothing, a significant difference (p < 0.05) was recognized for both the left and right erector spinae muscles (Muscles 5 and 6) and for both the left and right biceps femoris muscles (Muscles 7 and 8) in Procedure 1, and for the left Palmaris longus muscle (Muscle 4) in Procedure 2. Although a significant difference was observed for the erector spinae muscles and biceps femoris muscles among individual samples, there is no difference among different samples if the total amount of left and right muscle activity is compared.

Figure 5 also shows data while putting on the clothing. For Process 1, a significant difference (p < 0.05) was observed for the right Palmaris longus muscle (Muscle 3), both the left and right erector spinae muscles (Muscles 5 and 6), and the right biceps femoris muscle (Muscle 7) in Procedure 1, and for the left biceps brachii muscle (Muscle 2), left Palmaris longus muscle (Muscle 4), left erector spinae muscle (Muscle 6), and right biceps femoris muscle (Muscle 7) in Procedure 2.
Figure 6 shows data while removing the clothing. For Process 1, a significant difference (p < 0.05) was observed for the right biceps brachii muscle (Muscle 1) and right erector spinae muscle (Muscle 5) in Procedure 1, and the left Palmaris longus muscle (Muscle 4) for Procedure 2. Such a difference was also recognized for the left Palmaris longus muscle (Muscle 4) and right biceps femoris muscle (Muscle 7) in Process 2.

![Muscle activity ratio (when putting on the clothing)](image1)

![Muscle activity ratio (when removing the clothing)](image2)

Figure 4 Muscle activity ratio
(top: when putting on the clothing, bottom: when removing the clothing)
Figure 5 By-process muscle activity ratio (when putting on the clothing)
By-process muscle activity
(when removing the clothing , Process1)

By-process muscle activity ratio
(when removing the clothing , Process2)

Figure 6 By-process muscle activity ratio (when removing the clothing)

3.2 Work time

Work time for putting on / removing the clothing is shown in Figure 7, which indicates that the former process took longer than the latter. In Procedure 1, the work times for both putting on / removing the clothing were significantly shorter \((p < 0.01)\) than those of Sample 2.

Shown in Figure 10 are the work times for each work process. Significant differences were detected for Process 1 of Procedure 1 and Process 2 of Procedure 2 when putting on the clothing, and for Process 1 of Procedure 1 when removing the clothing \((p < 0.05, p < 0.01, \text{ respectively})\).
Figure 7 Total work times
(left: when putting on the clothing, right: when removing the clothing)

Figure 8 By-process work times
(top: when putting on the clothing, bottom: when removing the clothing)
3.3 Assessment of psychological workload

Figure 9 shows the results of fatigue duty sensation, where Item 1 shows ease of work and Item 2 shows burden of work. A significant difference (p < 0.05) was observed for all of the Items of both Procedures when removing the clothing, with Sample 2 being rated higher than Sample 1.

**Figure 9** Fatigue duty assessment results
(top: when putting on the clothing, bottom: when removing the clothing)
Mapped in Figures 10 and 11 are the sensations of burden on the whole body (Item 3), forearms (Item 4), upper arms (Item 5), waist (Item 6), and thighs (Item 7). The greater the value, the greater the sensation of burden is. A significant difference was observed for Procedure 2 when putting on the clothing and for Procedure 1 when removing the clothing (p < 0.01 and p < 0.05, respectively), and the sensation of burden was less for Sample 2 than for Sample 1 (Figure 10). In the results of assessment for each region (Figure 11), on the other hand, a significant difference (p < 0.05) was observed when removing the clothing in the upper arms, waist, and thighs for Procedure 1 and in the forearms for Procedure 2, and the sensation of burden was less for Sample 2 than for Sample 1.

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Figure 10 Sensation of burden on the whole body
(left: when putting on the clothing, right: when removing the clothing)
3.4 Impact of top design on the procedures of putting on / removing clothing

For the procedures of putting on / removing clothing for nursing care recipients who can move their upper limbs freely, Sample 1 (ordinary pajama-type) takes less time than Sample 2. However, the work time and psychological burden are not related. When removing the clothing, in particular, the psychological workload for Sample 2 is smaller than that for Sample 1.

For Procedure 2, which dealt with nursing care recipients with a paralyzed upper limb, the psychological burden for Sample 2 is less than that for Sample 1, particularly when putting on clothing, as the caregivers may use the fasteners on Sample 2 to open the shoulder parts wide.
4. Conclusion

In this research, the burden on caregivers when they put on / remove nursing care clothing tops was analyzed by way of EMG measurement, sensory tests, and videos of the procedures. By combining EMG measurement and sensory tests, it was made possible to quantify the workload, which could not be assessed solely on the basis of work time. The impact that nursing care clothing top design has on the workload and the impact of paralysis in the upper limbs of nursing care recipients were also investigated, with the conclusion that it is important to improve the design of nursing care clothing tops in order to reduce psychological workload. Also, the possibility was suggested that, by taking such an approach, nursing care products may be developed that will further reduce the burden on caregivers.

5. Reference


