Clinical Trial of Transfer Motion using Nursing-care Assistant Robot - Validation by Measuring EMG Signals

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1. Introduction

Nursing care is a very important job for helping person to regain health or achieve the quality of life. However, with the increase of senior citizen and people with disability, the shortage of caregivers (i.e., Personal Care Assistant, PCA) is becoming serious. In our research center, we have developed a nursing-care assistant robot (as shown in Fig.1). This robot was successful in lifting human up and transferring him/her between bed and wheelchair using its two human like arms [1, 2]. Stable lift-up motion has been tested for healthy subjects based on the knowledge obtained by analyzing the motion of professional caregivers[3].

In this research, in order to confirm the effectiveness of this robot and the lift-up motion, we conducted a clinical trial of patients in Nagoya City University Hospital. During this trial, every patient is lifted up and down three times. we measured the surface electromyography (EMG) signals of several muscles during the lifting-up and obtain the muscle activities. By comparing the changes of muscle activities of every operation, the efficacy of our robot and method is evaluated. This research was approved by Institutional Review Boards of Nagoya City University Hospital and RIKEN.

2. Operating Procedure

During trials, an operator controls the robot to lift patients up from bed and put them back three times. This lift-up motion has a 10-step operation, as follows:

1. **Start**: Move robot to starting location and initialize robot posture. (Fig.2(a))
2. **Forward**: Move robot near to the bed. (Fig.2(b))
3. **Sit**: Help patient sit up and move robot to insert robot's two arms under patient. (Fig.2(c))
4. **Close**: Close robot arms to contact patient's body (the backsides of trunk and thighs). (Fig.2(d))
5. **Up**: Lift patient up away from the bed. (Fig.2(e))
6. **Hold**: Move robot back away from the bed in some distance and close back to the bed again. (Fig.2(f))
7. **Down**: Lift patient down to bed. (Fig.2(g))
8. **Open**: Open robot arms away from patient's body. (Fig.2(h))
9. **Back**: Move robot back to extract robot arms from under patient and move robot back to starting position. (Fig.2(i))
10. **Finish**: Move robot to initial posture. (Fig.2(j))

During Step 1, 2 and 10, patient only lies on bed without being contacted. During Step 3, 4, 8 and 9, patient sits on bed with the support of operator. During Step 5, 6 and 7, robot makes contact with patient's body directly and applies force to lift his/her up.

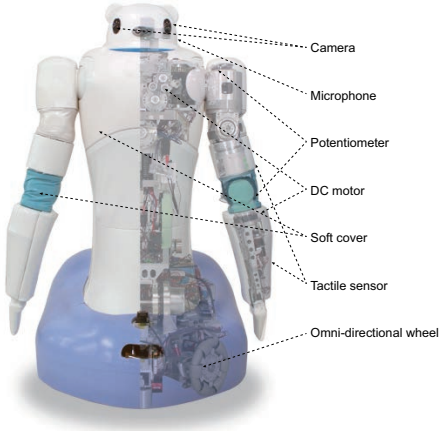

Fig. 1 Nursing-care assistant robot

3. EMG Measurement

During trails, surface EMG is measured to understand the muscle force applied by patient. Only the muscles on the frontsides of patient's trunk and thigh are measured due to robot arms would touch the backsides during lifting-up. EMG signals of five muscles on the left side of human body are measured (SCM, ABS, AEO, RF and VL). Fig.3 shows the measuring position of these muscles.

We remove the linear trends of the measured raw EMG signals and reduce the noise in a low-pass filter. Average EMG is calculated for every operation, which shows the change of muscle activities. In order to

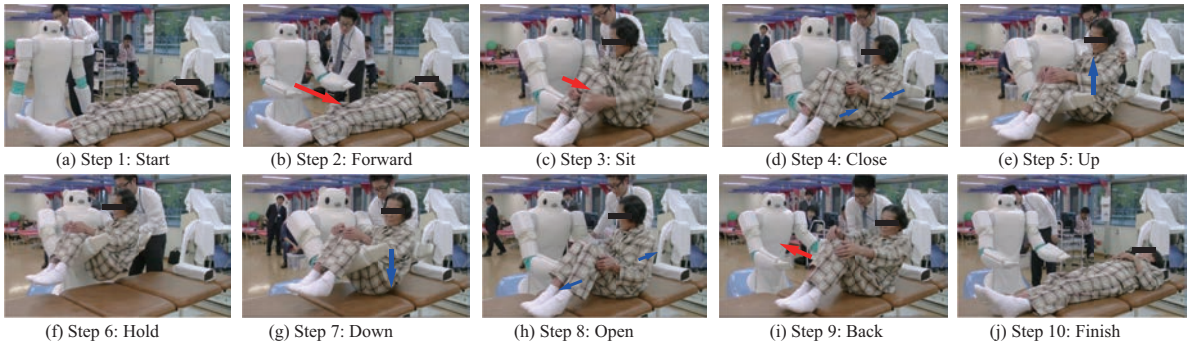

Fig. 2 Lift-up operations

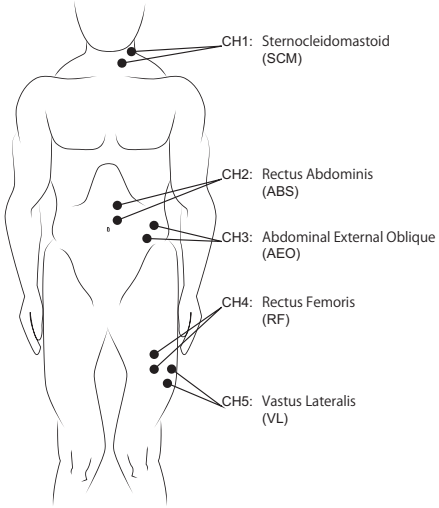

Fig. 3 EMG Measurement position

compare the results obtained on all trails, calculated average EMGs are normalized using the value of Step 4 - "Close".

4. Result and Discussion

This clinical trial was conducted for seven 34∼82 Y/O patients, 3 males and 4 females. Heights of patients are 1.49∼1.75 m. The mean height is 1.55 m. Weights are 37.2∼71.2 kg. The mean weight is 51 kg. All patients were weak in hip due to injury or illness. They were hard or impossible to move themselves between beds and wheelchairs.

We lifted every patient three times and succeed to get EMG signal 12 times. Fig.4 shows the filtered EMG signals of one lift-up trial of a patient. The changes of every operations were calculated using the average EMG. Fig.5 shows the change of average EMG during lifting-up of all patients. It also shows the change of the force applied by patients themselves. During the Step 1 and 2 ("Start" and "Forward"), both robot and operator would not contact patient and patient would only lie on bed. From the Step 3 ("Sit"), when operator and robot helped patient sit up, patient started apply torques and forces on muscles.

When robot lifts patients up (during Step 6 and 7), the forces applied on the muscles of hip and leg were reduced obviously. Patients can keep his/herself on robot arms without applying as large force as previous steps (Step 3∼5). It shows that our robot and the lift-up motion is effectiveness to lift patients up.

However, the value of CH1, which shows the force applied by patient on the neck, has a relatively-large change from Step 3. During lifting-up, patients had to take force to prop their head by themselves. During Step 3 and 4, others muscles also applied relatively-larger force due to patients should apply force by themselves to sit on the bed even with the support of operator and robot.

5. Conclusion

In this research, we carried out clinical trial to lift patients up using our nursing-care robot and the lift-up motion. We lift seven patients and measured their EMG signals from neck, abdomen and leg. The normalized average EMG signals shows that during the lifting-up (the Up, Hold and Down operations), patient can keep his/her body on robot arms with relatively-small forces. It shows the effectiveness of our robot in lifting human up. However, during lifting-up, patients still had to apply force to prop their head. And during Sit and Close operations, patients also had to apply force to sit on the bed by themselves. In the future, we should create new parts and motions to support patient's head during lifting-up and make patient easier to sit up.

References

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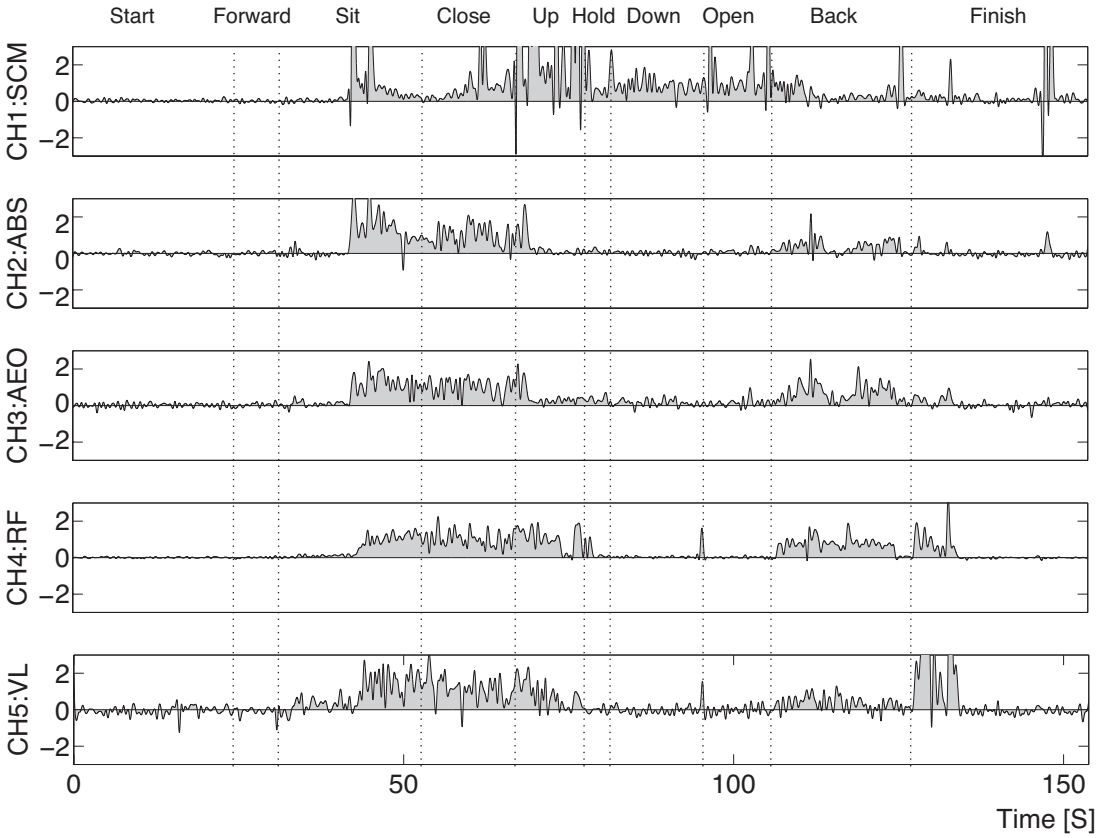

Fig. 4 Measured EMG signal of a patient

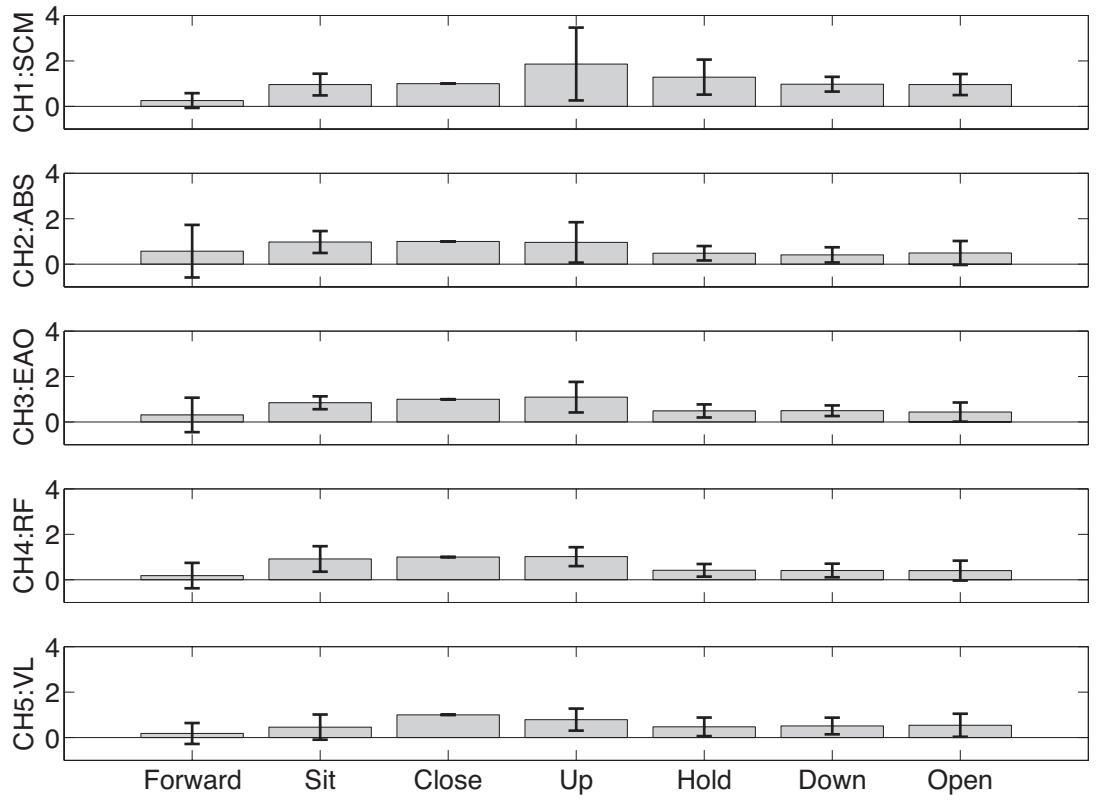

Fig. 5 EMG Change of during lifting-up