

## COMPARISON OF THREE METHODS FOR RAISING AN ELDERLY PERSON FROM A TRADITIONAL FUTON MATTRESS

KIKUE HIDAKA\*† AND KATSUKO KAMIYA

*Department of Graduate School of Comprehensive Human Sciences, University of Tsukuba,  
Tennodai, Tsukuba-city, Ibaraki, 305-8575, Japan*

*\*E-mail: kikue@sakura.cc.tsukuba.ac.jp*

The objective of this study was to compare three approaches for a caregiver to raise an elderly person from a Japanese traditional futon mattress placed directly on the floor. These approaches are as follows: raising from behind with the support of the back (method A); straight raising of the trunk (method B), and raising through the use of the caregiver's own rotational motion (method C). The methods were evaluated from the perspective of caregivers and care recipients. The caregivers were 12 nurses and the recipients were 40 elderly persons. Heart rate, surface electromyography and subjective evaluation of physical burden and ease of performance were evaluated in the caregivers, and "stability", "discomfort" and choice of the best method were evaluated subjectively by the elderly persons. The results indicated that method A caused more stress on the lumbar region of caregivers and was more difficult to perform than methods B and C. No significant difference in physical burden was found between methods B and C; however, method C had a lower physical burden and could be performed with ease. For care recipients, the approaches of choice were methods A and C; many preferred method C, while desirable methods of care varied between individuals and lifestyle and mental factors played a role in this decision.

**Key words:** surface electromyography; percent heart rate range; load on caregivers' body; subjective evaluation of care recipients; home care

### INTRODUCTION

The traditional sleeping style in Japan is to lie on a mattress ('futon' in Japanese) spread directly on a rush-made mat ('tatami' in Japanese) of the floor, and this style is still popular among Japanese people. However, when the elderly require long-term nursing care due to disease and muscle weakness (hereafter referred to as care recipients), many change their sleeping style from the use of a futon mattress to a bed. The main reasons for this are to allow a caregiver to perform medical and nursing practice more easily and with less pain to the elderly person in position changes and movement (Yokoo, 1996).

However, some care recipients still use a futon mattress due to dementia, prevention of turning over, housing conditions (Tsukui, 1992) and lifestyle habits. In fact, approximately 20% of bedridden care recipients use futon mattress (Welfare Bureau of Tokyo Metropolitan Government ed, 1996; Sato et.al., 2000). Whereas many studies of nursing care skills for bedridden persons have been conducted (Tabata et al., 1990; Kumagai et al., 1993; Shibata et al., 1998; Yanagihashi et al., 1999; Ito, 2000; Shibata et al., 2000), only one (Mafune et al., 1992) has examined these skills for care of elderly persons who are bedridden on a futon mattress.

Therefore, we evaluated the skills required to lift a person from a futon mattress, which is a hard task for a caregiver. Evaluation of the lifting method from the perspectives of caregivers and care recipients is of importance; therefore, we compared three approaches to raising a person from a futon

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mattress, with evaluation of the load for the caregiver and the perceived safety and ease for the care recipient.

## MATERIALS AND METHODS

### *Evaluation of skills*

The three studied methods for raising a care recipient from a futon were as follows: method A, an approach described in common home-care handbooks, in which a caregiver raises the person supporting his/her back (Care Service Study Group, 2000); method B, a method introduced into rehabilitation and nursing care practice, in which the caregiver sits beside the care recipient face to face and raises the trunk directly (The Physical Therapy Department of Kanagawa General Rehabilitation Center, 1998, Terasaki, 1998); and method C, a newly developed method in nursing care practice, in which the caregiver raises the care recipient with the help of rotation of the caregiver (Kamiya, 2000) (Figure 1).

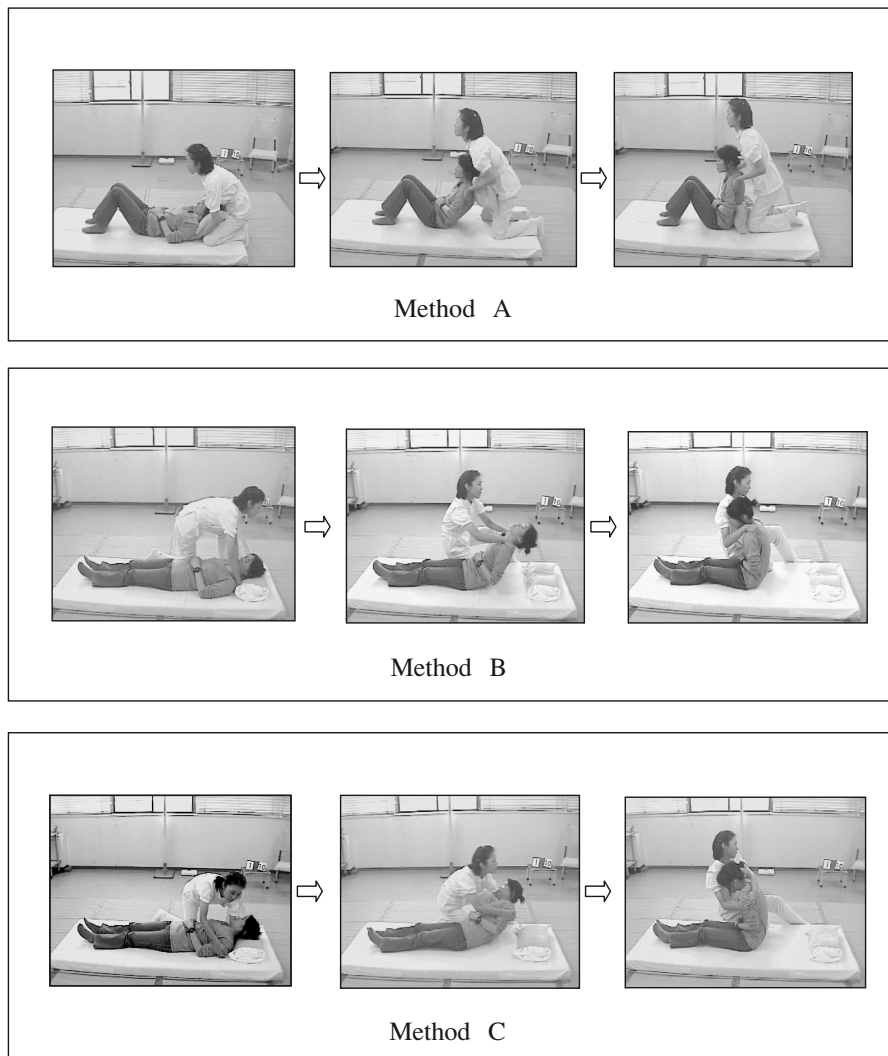


Fig. 1. Three methods for raising an elderly person from a futon mattress placed on the floor.

*Method A*

1) The care recipient raises the knees and crosses his/her arms on the abdomen. 2) The caregiver places their hands under the armpits of the care recipient from behind. 3) The caregiver pushes a pillow with their leg and inches forward to raise the care recipient.

*Method B*

1) The care recipient crosses his/her arms on the abdomen. 2) The caregiver sits beside the care recipient face to face, puts the right knee alongside the care recipient, and raises recipient's left knee. 3) The caregiver puts their hands beneath the shoulder blades of the care recipient. 4) The caregiver shifts the center of their own mass from the left leg to the right leg to raise the person from a futon mattress.

*Method C*

1) The care recipient crosses his/her arms on the abdomen. 2) The caregiver sits besides the care recipient, holds the right knee against the right flank of the care recipient, and raises the left knee. 3) The caregiver slips their left hand under the neck of the care recipient, slips the right hand under the body of the care recipient, and holds hands beneath the left shoulder blade. 4) The caregiver shifts the center of their own mass to arc the head of the person on the right side of the body axis and raise the care recipient from a futon mattress.

*1. Caregivers**Subjects*

The caregivers were 12 hospital nurses (Table 1). The mean age of the caregivers was  $30.4 \pm 5.2$  years, and their mean duration of work experience was  $7.4 \pm 3.5$  years.

*Measurement procedure*

Table 1. Characteristics and anthropometric dimensions of the caregivers studied.

Characteristics and dimensions	(n=12)	
	Mean	SD
Age	30.4	5.2
Work experience (year)	7.4	3.5
Height (cm)	158.9	5.3
Weight (kg)	51.5	6.9
BMI (kg/m <sup>2</sup> )	20.4	2.5
Sitting height (cm)	84.0	4.1
Arm length (cm)	67.1	3.3
Grasping power (kg)	27.6	3.3

To simulate the conditions under which a caregiver lifts a care recipient into a sitting position at home, a mat (length: 193 cm, width: 83 cm, thickness: 8 cm) was placed on the floor. After sufficient practice of the skills required for methods A, B and C, nurses performed the tasks on a "simulated patient" (age: 23 years, height: 165.5 cm, weight: 64.0 kg). The order of performance of the three skills was randomly designated for each nurse. Before the beginning of the evaluation, the nurse rested for 10 minutes and heart rate was determined for 90 seconds before completion of the resting time (Figure 2). Upon hearing a metronome sound, the nurse repeated the same skill 10 times at 10-second intervals and an electromyograph recorded surface electromyograms. The heart rate was determined again for 90 seconds immediately after completion of each skill. A 10-minute rest period was allowed between evaluation of each skill. In all tests, the performance of the nurses was recorded

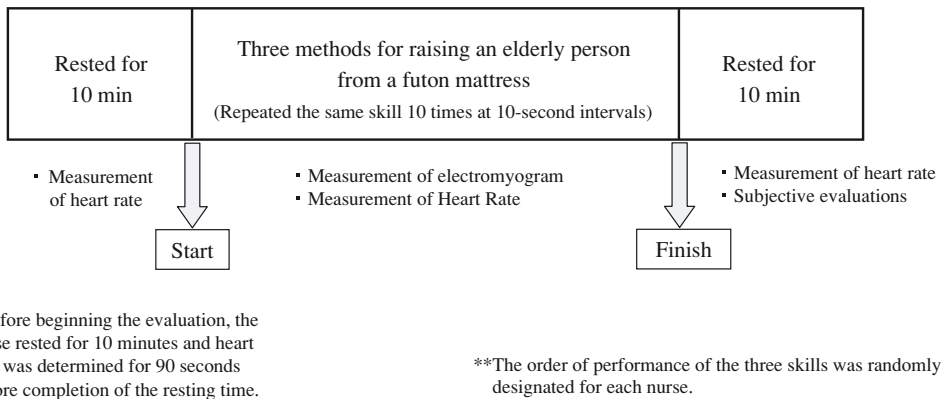


Fig. 2. Measurement procedures for the caregiver (nurse).

with a video camera from two viewpoints: the side and the heels of the “patient”.

### Endpoints

#### 1. Heart rate and surface electromyograms

Heart rate was determined as a measure of systemic stress strains and surface electromyograms were recorded as a measure of local load.

Surface electromyograms of the trapezius and biceps brachii muscles are generally used to determine the load for the upper extremities. In this study, however, the biceps brachii muscles of the caregiver made contact with the head and neck of the care recipient while raising the person from a futon; therefore, surface electromyography was performed only for the trapezius muscle. There is also a large physical burden on the muscles of the lower extremities of the caregiver; however, in measuring this burden the electrodes of the surface electromyograph made contact with the body of the care recipient and the floor, and for this reason measurements on the lower extremity muscles were not included in the endpoint evaluation. To determine the physical burden on the back of the caregiver, surface electromyography was conducted on the erector spinae muscles.

Electrodes for surface electromyography were attached to the descending part of the right and left trapezius muscles (the region between the neck and each shoulder) and the erector spinae muscles of the right and left lower back (3 cm from the spine between the 3rd and 4th lumbar vertebrae), and an earth electrode was attached to the 7th cervical spinous process. Using biomedical electrodes (NT-511G, Nihon Kohden Corporation) and a multi-telemeter system (WEB-5000, Nihon Kohden Corporation), an electromyograph was recorded (bipolar lead, time constant: 0.03 sec, sensitivity: 0.5 mV/V). Electrical signals introduced from each body region were loaded onto a personal computer at a sampling frequency of 1 kHz via an A/D converter (Power Lab/8s, ADI) and saved on a hard disc (Power Macintosh 6200/75, Apple Computer, Inc.). Heart rate and the surface electromyograms were analyzed using software for electromyography (Power Lab Chart 3.6, ADI). Analysis of motion was limited to that associated with raising the care recipient, since this produced the highest body strains. The obtained surface electromyograms were divided and extracted for each motion with motion artifacts eliminated by means of 10-Hz high pass filter; subsequently, the peak magnitude values and integrated electromyographic values after full wave rectification were estimated (Shibata et al., 2000). Regarding the heart rate, the percentage heart rate reserve (%HRR) was estimated, since %HRR can be standardized for age and individual variability (Shibata et al., 2000). Each of these values was calculated as  $\%HRR = (\text{working heart rate} - \text{resting heart rate}) / (\text{maximum heart rate} - \text{resting heart rate}) \times 100$ .

### Subjective evaluation

“A feeling of a physical burden” in repeating care skills (i.e., fatigue) is a subjective complaint

and may not be assessed quantitatively (Kimura, 1987). In this study, a subjective evaluation was conducted in addition to recording determination of heart rate and electrocardiograms. “A feeling of a physical burden” was defined as “fatigue, pain and numbness” and was evaluated for 7 body regions (forearm, upper arm, shoulder, back, lumbar, femur and lower leg). The total score for the 7 regions (0 to 5 points each) was used to assess the systemic burden. The ease of performance of the three methods was also rated on a five-point scale, similarly to assessment of physical burden.

## 2. Care recipients

### *Subjects*

The subjects were 40 elderly persons (29 males and 11 females) aged 60 years or more with the mean age of  $66.7 \pm 3.4$ , who lived their daily lives independently in a community. None of them had musculoskeletal or nervous system diseases or injuries (Table2).

Table 2. Characteristics and anthropometric dimensions of the elderly care recipients studied.

Characteristics and dimensions	Total (n=40)		Male (n=29)		Female (n=11)	
	Mean	SD	Mean	SD	Mean	SD
Age	66.7	3.4	66.8	3.5	66.5	3.3
Height (cm)	158.0	8.5	161.8	6.1	148.1	5.6
Weight (kg)	58.0	9.5	59.6	8.0	53.7	12.0
BMI (kg/m <sup>2</sup> )	23.2	3.3	22.7	2.4	24.4	4.9
Sitting height (cm)	83.9	4.3	85.5	3.6	79.7	3.3

### *Measurement procedure and endpoints*

Each of the three methods was performed three times for each subject by the same caregiver and the order of performance of the three skills was random. After completion of all three skills, the care recipient evaluated the three skills from a perspective of “ease”, “stability”, “comfort” and “discomfort”. In addition, the care recipient was asked to choose which method they liked the best and the reason for this choice.

### *Data analysis*

Heart rate and peak magnitude and integrated values on the surface electromyograms were tested using ANOVA with a Latin square design and Tukey’s multiple comparison. Spearman rank-correlation coefficients were calculated for the peak magnitude and integrated values. All items in the subjective evaluation were studied using a  $\chi^2$  test, with a significance level of 0.05. Statistical analysis was conducted using SPSS Base 10.0J (SPSS Inc.).

### *Ethics*

The objectives and contents of the study were explained to the subjects both verbally and in writing and informed consent in writing was obtained from all the subjects. Each subject was informed that they could withdraw from the study at any time, that individual information and study results were to be used only for research purposes and that protection of privacy was guaranteed.

## RESULTS

### *1. Caregivers*

#### *Heart rate and surface electromyograms*

The level of %HRR after 10 repeated sessions of each method was the highest for method A,

followed by methods C and B (Figure 3). A significant difference was found between the methods and the increase in heart rate was significantly higher in method A than in method B ( $p < 0.05$ ). Regarding the wave forms of the electromyograms, the magnitude of the right and left trapezius and erector spinae muscles was generally higher in method A and the extent of use of the right and left erector spinae muscles varied during raising the care recipient (Figure 4). In method B, use of the right trapezius and the erector spinae muscles increased simultaneously during raising of the care recipient, and use of the erector spinae muscles changed with a shift in the center of body weight. In method C, the discharges of the right and left trapezius muscles were synchronized in supporting the neck of the care recipient and use of the erector spinae muscles increased in rotating the care recipient.

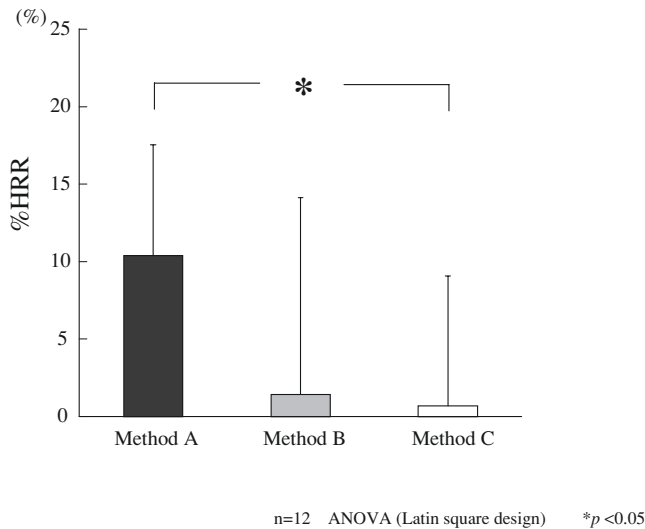


Fig. 3. Comparison of the percent heart rate range of caregivers.

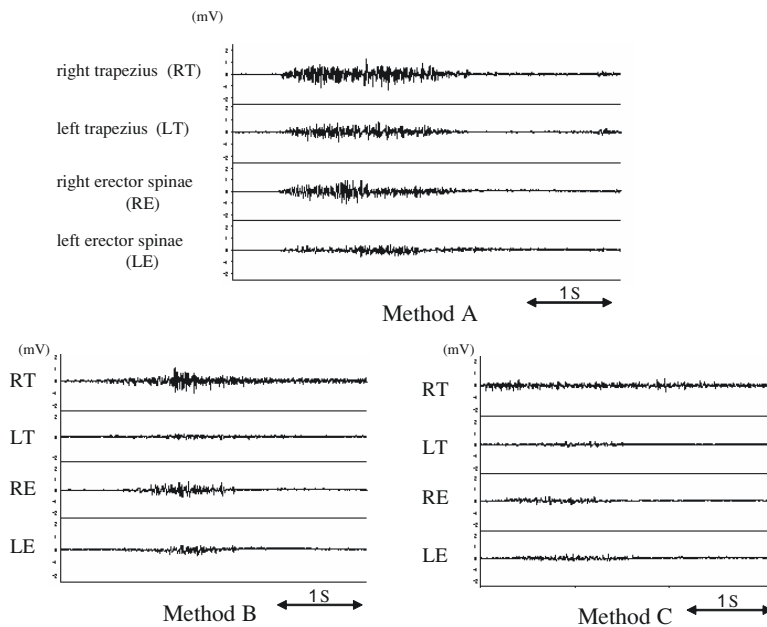


Fig. 4. Surface electromyograms of a caregiver.

In additional experiments, surface electromyography was performed in caregivers holding 3-kg dumbbells for 15 seconds with the trunk flexed forward at  $60^\circ$  to obtain the maximum voluntary contraction (MVC) values. The peak magnitude and unit-time integrated values in performing each skill were converted into ratios relative to the MVC (1.0). The peak magnitude of the right trapezius muscle was the highest ( $7.23 \pm 5.60$ ) in method A, followed by that in methods B ( $5.10 \pm 4.83$ ) and C ( $4.15 \pm 4.66$ ); this value was significantly higher in method A than in method C ( $p < 0.01$ ). The peak magnitude of the left trapezius muscle was the highest ( $8.84 \pm 7.75$ ) in method A and significantly higher than that in method B ( $p < 0.01$ ). The peak magnitudes of the right and left erector spinae muscles were significantly higher in method A than in methods B and C ( $p < 0.01$ ). The integrated value of the right trapezius muscle was  $3.70 \pm 3.25$  in method A, which was significantly higher than that in method C ( $p < 0.05$ ). The integrated values of the right and left erector spinae muscles in method A were also significantly higher than those in methods B and C ( $p < 0.01$ ,  $p < 0.05$ ; Figure 5). A strong correlation was found between the peak magnitude and the integrated value for the same muscle.

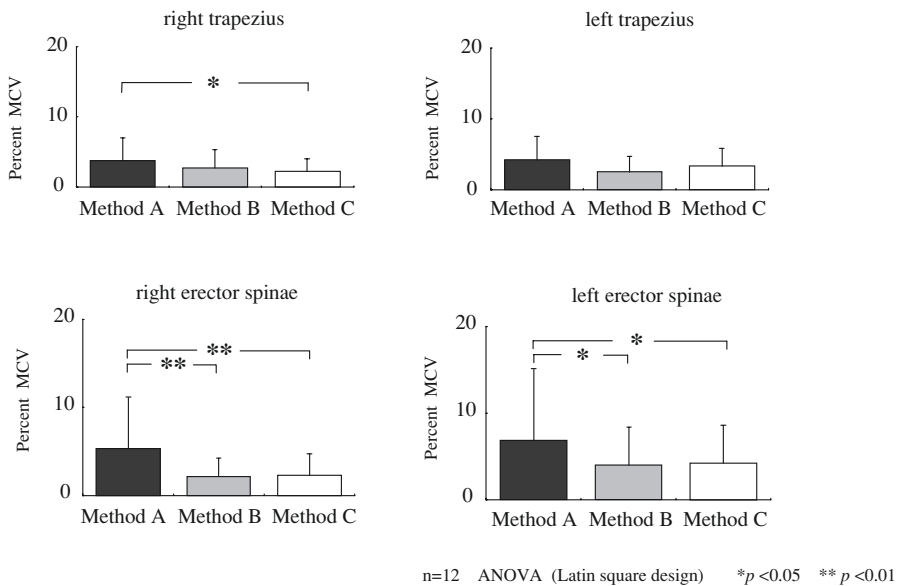


Fig. 5. Comparison of the integrated levels of electromyograms of caregivers.

### Subjective evaluation

There were significant differences in the total score for “a feeling of physical burden” among the methods, and this value for method C was significantly lower than that for method A or B ( $p < 0.01$ ). The score for the ease of performance was significantly higher for method C compared to method A or B ( $p < 0.01$ ; Figure 6).

### 2. Care recipients

Thirty-two (80.0%) of the 40 subjects used a futon mattress. Most care recipients chose method A or C as superior from the perspective of “ease”, “stability”, “comfort” or “discomfort”, while no significant difference was found between the rates of care recipients choosing these methods (Figure 7). Regarding the desirability of each method, 21 persons (52.5%) chose method C ( $p < 0.05$ ), and regarding this method 10 of the 21 subjects stated that “I feel safe because the caregiver keeps me steadily.” On the other hand, many felt that “the neck was unstable”, and there was the general opinion that “there was a feeling of pressure on the shoulder” by in the case of method B.

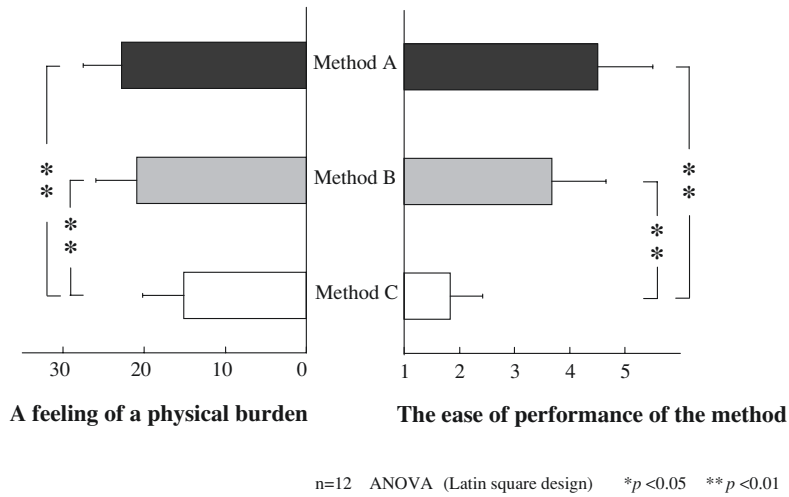


Fig. 6. Comparison of the subjective evaluations of the caregivers.

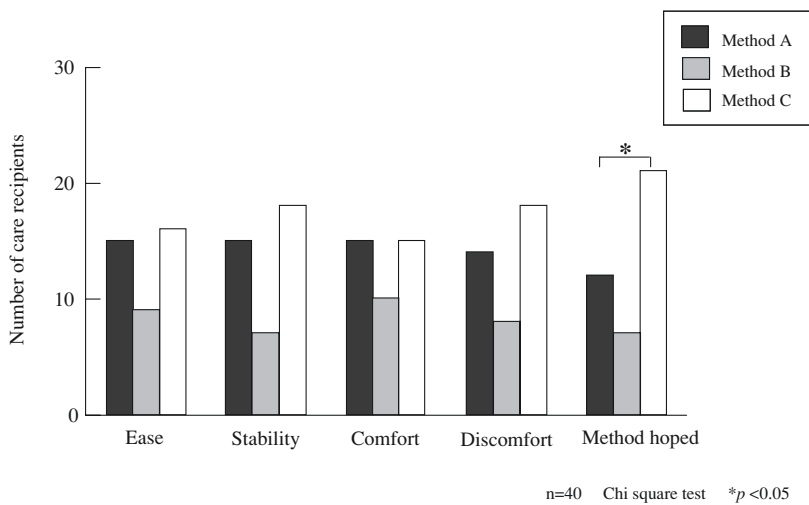


Fig. 7. Comparison of the subjective evaluation of the elderly care recipients.

## DISCUSSION

### *Comparison of heart rate changes, surface electromyograms and the subjective evaluation of caregivers*

The comparative study of the three skills for raising a care recipient showed that %HRR was higher in method A than in methods B and C and that the myoelectric activities of the erector spinae muscles and the feeling of a physical burden on the caregiver were more pronounced in method A than in the other two methods.

Method A did not appear to place a major physical burden on the erector spinae muscles (i.e., the lumbar region) because the forward bending of the trunk was not remarkable, as noted in video images. However, the simultaneous actions of “pushing a pillow with both the legs” and “proceeding forward” while holding the care recipient’s upper body with the arms may have caused an increase in myoelectric activities of the erector spinae muscles. In addition, the caregiver was required to perform two simultaneous actions with the arms (i.e., “holding up the care recipient with hands placed



under the armpits” and “pushing the care recipient”); therefore, the caregiver had difficulty in keeping balance due to the opposite actions of the upper and lower extremities, and this led to an increased physical burden in the muscles and a general feeling of strains.

%HRR and surface electromyography did not differ significantly between methods B and C; however, using method B the caregivers felt a severe physical burden and had more difficulties in raising the care recipient. The points of the upper arm, shoulder and back were high in method B, suggesting that an awkward shift of the center of body weight increased the burden on the upper arm. The burden on the arm muscles could not be determined directly because the electrodes placed on the upper arm and forearm touched the neck of the care recipient. Based on the kinetics, direct raising of the trunk of the care recipient in method B required the caregiver to raise the care recipient with both the arms extended; therefore, the moment of the arm was long and the center of body weight of the care recipient was distant from that of the caregiver in this method. These conditions made it difficult to shift the center of body weight smoothly and increased the physical burden over a region from the arm to the lumbar area.

In method C, the caregiver held the back of the neck of the care recipient with both the arms and the centers of body weight were close to each other. In this position, the caregiver could raise the care recipient with the assistance of their own rotational motion. Furthermore, although the rotating action made the lifting distance longer in method C, it required less instant force than a straight action. This mechanism may have accounted for the better results in evaluation of method C, compared to method B. Determination of the physical burden on the biceps brachii and quadriceps femoris muscles, in addition to the trapezius muscle, might provide further details of the difference between methods B and C, including aspects of dispersion of the physical burden.

Nursing care skills involve complex movements, including rotational motion, and the serial body movements of a care recipient have an effect on the corresponding movements of the caregiver. This may limit the number of muscles for which the physical burden can be determined, but overcoming the limits on such measurements should be sought since this would lead to more appropriate determination of endpoints for evaluation of physical burden.

#### *Subjective evaluation by care recipients*

Most care recipients favored method A or C based in terms of all the subjective evaluation items used, including “stability”, and approximately half of them chose method C as the most desirable method.

The care recipients felt the stability of method A was positive, given the support of the upper body of the care recipient from behind and over a large area. Therefore, the mental effect of reassurance that there was no risk of a backward fall had an effect on the results. In contrast, method B was not chosen by most care recipients because the area over which support was given was less than those for methods A and C and because no support was provided for the head of the care recipient; this made the subjects feel unsteady and did not provide them with sufficient stability. However, comments on method A were contradictory, with one answer being “I feel safe while being raised from behind”, and another being “I don’t feel at ease because I cannot see what is being done behind me”. Contradictory answers were also found for method C, including “I feel safe because I am wrapped up” and “I somehow feel that I am being pushed”. Previous reports have suggested that patients have performance-based and emotional demands, including dependence on caregivers and concerns regarding the tenderness of their approach (Ujiie, 1995). Similarly, the mental state of care recipients was of importance in evaluation of care skills, while requested care skills may vary between individuals and depend on lifestyle and mental factors.

We should note that the raising skills were evaluated based on changes in heart rate and surface electromyograms, and this may have limited a sufficient assessment of the physical burden. Therefore, further studies should be conducted with more endpoints and subjects, including 3D motion analysis. Also, since care skills associated with futon mattress are often used in home care, three skills should be evaluated by taking into account all ethically allowable conditions of home care

for elderly subjects.

## CONCLUSION

We compared three kinds of skills required to raise a person from a futon mattress by means of analyzing the raising performance from a perspective of ease for the caregiver and with regard to safety and ease for the care recipient.

1. Results for heart rate changes, surface electromyograms and subjective evaluation suggested that method A, in which the care recipient was raised with the support of the back from behind, caused more burden on the lumbar region and was more difficult to perform, compared to methods B and C. No significant difference in physical burden was found between methods B and C; however, method C, in which the care recipient was raised through the use of the caregiver's own rotational motion, appeared to have less associated physical burden and could be performed with ease.
2. For the care recipients, methods A and C were considered the best. Many care recipients preferred method C, but desirable care skills varied between individuals and lifestyle. The results showed that mental factors would need to be considered in the choice of an appropriate method.

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## REFERENCES

- Care Service Study Group (2000) Basic Knowledge for Care Practice in 100 Q&As. Jiho, Tokyo, pp. 46.
- Ito, A (2000) Support skills to raise an elderly person: motion patterns of rolling-over and sitting-up in the elderly and comparison of two support skills. Dissertation, *Tsukuba Graduate School*.
- Kamiya, K (2000) ABCs of Home: Care Easy!, Nursing Science Academy, Tokyo: pp. 51-52.
- Kimura, A (1987) Fatigue: study methods for muscular fatigue, *General Rehabilitation.*, **15**: 585-590.
- Kumagai, K, Kodama, F, Konno, S, Saito, M, Sasaki, H, Sasaki, M, Toita, H, and Tida T (1993) Comparison of position changes and shifts using electromyography. *Clinical Study*, **14**: 960-965.
- Mafune, T, Fukase, S, and Watanabe, N (1992) Study of nursing care actions from the perspective of shift of the center of body weight: methods to change the position of a home-care patient from the supine to the sitting position. *J. Japan Academy of Nursing Science.*, **12**: 46-47.
- Sato, K, Emori, Y, Matsumura N, Nitta, A, and Katsuko, K (2000) Care for persons at home and sleeping style. *J. Japanese Society of Nursing Research.*, **23**:174.
- Shibata, M, Shibata, S, Nishida, K, and Hirata, M (1998) Differences in support skills for body shift and local burden on caregivers. *J. Japanese Society of Nursing Research.*, **21**: 125.
- Shibata, S, Shibata, M, Katayama, M, Yoshioka, T, and Hirata, M (2000) Effects of differences in support skills for sitting-up. *J. Japanese Society of Nursing Research.*, **23**: 43-53.
- Tabata, S, Hosono, K, Nakano, E, Maeda, T, and Kosaka, K(1990) Effective method for a shift from a supine to a sitting position in bed – analysis by electromyography and video recording. *Progressive Clinical Nursing Care*, **2**: 167-172.
- Terasaki, A ed. (1998) Visual Home Care: why do it? Hitotsubashi Publishers, Tokyo, pp: 39.
- The Physical Therapy Department of Kanagawa General Rehabilitation Center (1998) Support and instruction to the elderly with disabilities and prevention of a bedridden status, Pacific Supply, Osaka: pp. 73.
- Tsukui, J ed. (1992) Selection for Care Workers. 15. Care skills. Kenpakusha, Tokyo, pp.75-76.
- Ujiie, S (1995) What are care skills?: nursing skills established by interaction between nurses and patients, *J. Clinical Nursing*, **21**: 1846-1849.
- Welfare Bureau of Tokyo Metropolitan Government ed.(1996) Elderly life: statistics in 1995, Tokyo: pp. 90.
- Yanagihashi, R, Kobayashi, C, Shinohara, C, Kimura T, Ohira, M, and Fuziwara, T (1999) Physiological and mental burdens in body shifting approaches. *J. Japanese Society of Nursing Research.*, **22**: 15-23.
- Yokoo, H (1996) Home-care practice course. Chuohoki Publishers, Tokyo: pp.90.