QUANTITATIVE ANALYSIS OF CARE-GIVING MOTION USING A 3-D MOTION ANALYSIS

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Abstract: In order to clarify quantitatively the characteristics of the "skillfulness" of care-giving motion, the care-giving motions among trained caregivers and unskilled caregivers were investigated with the client's motion. The targeted motion is the movement that caregiver lets the client lying on the bed sit. The subjects are three trained and four unskilled caregivers. The motions of the care-giver and the client were recorded simultaneously by 3D motion analysis system. The trajectories, velocities and accelerations of the center of gravity (COG) were investigated. The COG trajectories of trained caregivers showed good coincidence among three trials, and displayed smoother curves than those of unskilled caregivers'. The COG velocity curves of trained caregivers had a single peak at first, whereas the unskilled caregivers' showed plural little peaks during the motion.

Introduction

To meet the necessity of caregiving in aged society, it is indispensable to bring up more skilled caregiver in a shorter training time.

So far, it is thought the trainees acquire the skill empirically by repeating the care-giving motion. The evaluation of the skill of the caregiver has been done intuitively. This prevent the quantitative analysis on the educational method of care-giving motion. The purpose of this study is to clarify the characteristics of the trained caregivers' motion and analyze the "skillfulness" quantitatively.

The 3D motion analysis has been used to evaluate the motion quantitatively. The point that the care-giving motion is more special compared with other operations is that the care-giving motion include the interaction with the client.

In this paper, both the caregivers' and the client's motion were analyzed at the same time. And focusing on the movement of their center of gravity (COG), the trajectories, velocities, accelerations of their COG were analyzed.

Methods

The motion raising the client lying on the bed up to sitting position was investigated. The subjects are three female trained caregivers and four female unskilled caregivers. The trained caregivers had more than 12 years clinical experience. Their body height ranged from 153 to 160 cm and the weight ranged from 50 to 56 kg. The unskilled caregivers were undergraduate students in the physical therapist course. Their body height ranged from 155 to 162 cm and the weight ranged from 44 to 60 kg. The client role was performed by a male volunteer, who was asked to keep relaxed status.

The caregiving examinations were done three times by each subject taking a brief rest between trials. The care-giving motion and the client's motion were recorded simultaneously by VICON 3D motion analysis system (Oxford Metrics, UK) . The subjects and client were equipped with the 16 infrared reflective markers (Figure 1).

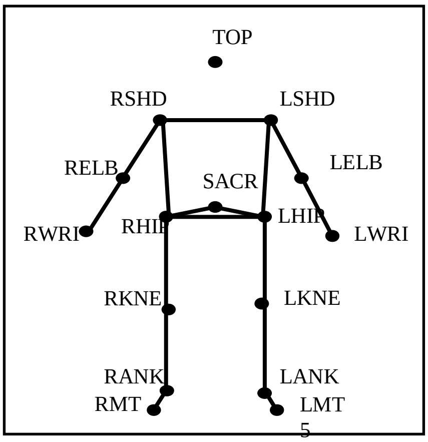

Figure 1: The attached points of markes

A three –dimensional space was defined as follows:
X-direction: Direction from client's left side to the right side
Y-direction: Direction from client's head side to the foot side
Z-direction: Vertical direction from lower side to the upper side

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Analysis:

The data were sampled at 120 Hz and smoothed with an upper cut-off frequency of 6 Hz.
In order to evaluate the motion, the center of gravity (COG) of caregivers and the client were calculated as follows:
The whole body was divided into eleven segments: right and left upper arms, lower arms, thighs, lower legs, foots, head and trunk. From the position of the reflective markers, the COG in each segment was calculated using the mass ratio of the body each part. Using these weighted averages, the COG of the whole body was calculated.

We described for COG trajectories as follows:

- shapes of COG trajectories
- the correlation of caregivers' COG trajectories and the client's
- mean total length of the COG trajectories

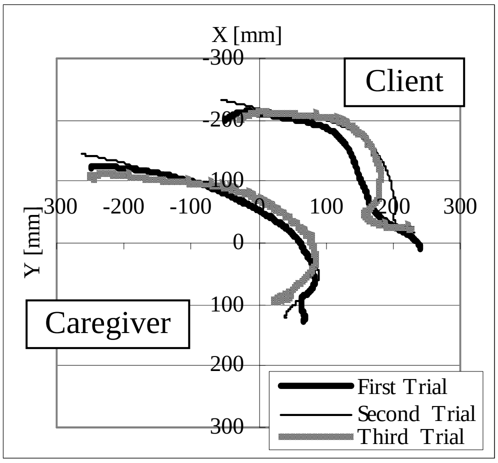
$$\sum\sqrt{\left(x_{i+1}-x_i\right)^2+\left(y_{i+1}-y_i\right)^2+\left(z_{i+1}-z_i\right)^2}$$

In addition, the COG velocities and the COG accelerations of caregivers were described.

Results

The typical COG trajectories of the trained caregivers and the client was displayed on the x-y plane (Figure 2a). The COG trajectories of three trials showed similar shape, and the smooth curve of the trajectories resembled each other. The mean total length of the COG trajectories for caregivers was 542.4 ± 31.80 mm and that for client was 505.6 ± 34.24 mm.

(a)



(b)

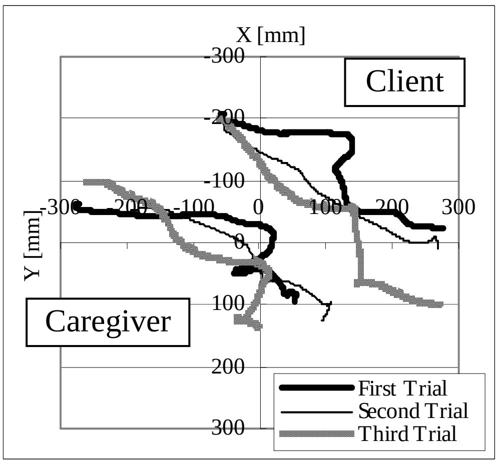
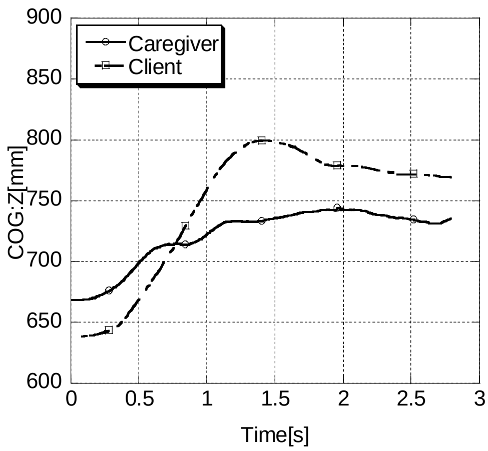


Figure 2: The typical COG trajectory of caregiver and client in X-Y (horizontal) plane

(a) Trained caregiver
(b) Unskilled caregiver

(a)



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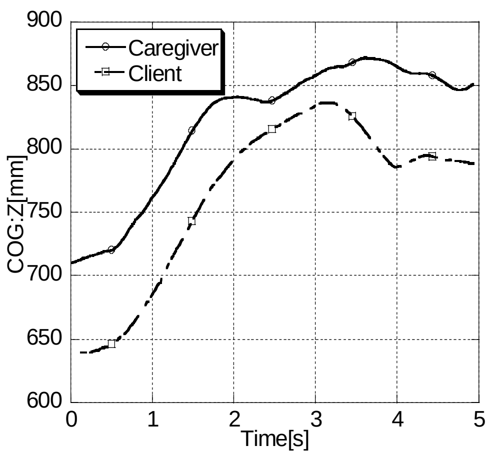

Figure 3: The typical COG trajectory of caregiver and client in Z (vertical) direction

(a) Trained caregiver

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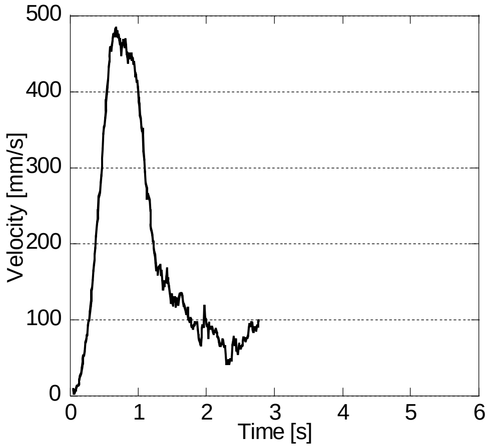
(b) Unskilled caregiver

(a)



(b)

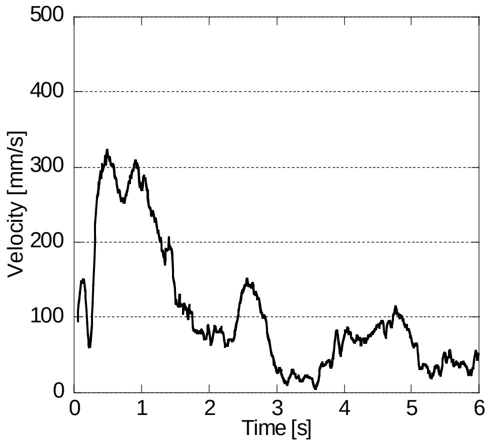


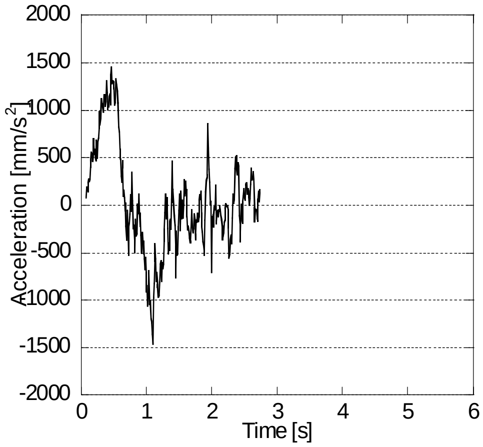
Figure 4: The typical COG velocity of caregiver
(a) Trained caregiver
(b) Unskilled caregiver

The caregiver’s COG trajectories and the corresponding client’s drew similar shapes, and showed a high correlation (values of R^2: 0.955 along with x-axis, 0.916 along with y-axis, 0.880 along with z-axis).

In the case of the unskilled caregivers, the COG trajectories were rather jerky and the shapes of each trials showed poor agreement (Figure 2b). The mean total length of the COG trajectories for caregivers was 647.1±57.43 mm, and that for client was 633.7 ± 55.17 mm. These results were longer than those of the trained caregivers’ case. Only the correlation between the caregivers' COG trajectories and the client's COG trajectories showed a high correlation as for trained caregivers (values of R2: 0.944 along with x-axis, 0.901 along with y-axis, 0.954 along with z-axis)..

Figure 3 shows the typical COG trajectories in vertical direction. The COG of trained caregiver was higher than client's at the beginning of the motion, then it kept lower position afterward (Figure 3a), while the COG of unskilled caregiver moved higher position than clients’ all the time (Figure 3b). And the change of COG was smaller in the trained caregiver than in the unskilled caregiver.

(a)



(b)

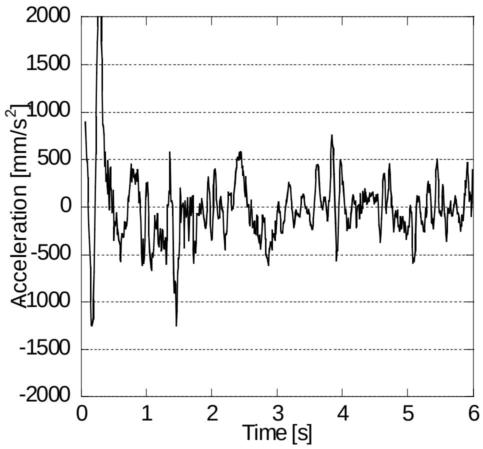


Figure 5: The typical COG acceleration of caregiver
(a) Trained caregiver
(b) Unskilled caregiver

The representative changes of COG velocities and COG accelerations are shown in Figure 4 and Figure 5, respectively. The COG velocity of the trained caregiver increased sharply at first and then decreased, showing a single peak. The highest speed ranged from 400 to 480 mm/sec among three subjects, and the total time of the caregiving motion was 2.76 ± 0.04 seconds on the average. While in the unskilled caregiver, the COG velocity did not increase as much as those of skilled subjects and there showed several low peaks. The highest speed ranged from 200 to 320 mm/sec among four subjects, and the total time was 5.58 ± 0.63 seconds on the average.

Discussion

Based on the biomechanics of skilled operation and it’s education method, several studies have been reported. Uno[1] pointed out that the smoothness was the criterion of the skilled movement when one moves the hand between pairs of targets in the horizontal plane.

Flash[2] observed subjects tended to generate smooth curved trajectories with single peaked, bell-shaped speed profiles during reaching action.

In this paper, we analyzed the care-giving motion focusing on the movement of the COG. In trained caregivers, the COG trajectories were shaped as a smooth curve, and the COG velocities drew the shapes of bell type. While in the unskilled caregivers, the trajectories of COG were not smooth and there were several low peaks in the velocity curve. These findings showed good agreement with the Flash's results. At the beginning, the trained caregivers rapidly raised up the client's upper half of the body, then they got down their COG and heaved client's body and changed front at once. So they ended operation by acceleration once and the deceleration. The unskilled caregivers had to add power at many times, because the acceleration at the beginning was small. Viewed in this light, it was regarded that the smooth curved trajectory and the bell shaped velocity curve were characteristics of skilled operations. They did efficient operation moving dynamically.

Additionally about the trajectories in vertical direction, the COG of trained caregivers moved mainly at lower position than clients', but unskilled caregivers' moved higher position all the time. The unskilled caregivers did operation by which tried to raise the client up, while the trained caregivers lowered their COG, supported the client, and moved. This is another one of the characteristics of trained caregivers, and the change of COG became small and the load of body lightened by that.

Moreover we analyzed caregiver's COG and client's COG at the same time. Trajectories of two COG drew similar shapes, and showed a high correlation in both trained and unskilled caregivers.

The unskilled caregivers could not draw a smooth trajectory. Their COG trajectories were erratic shapes. So it was seemed that the client's COG was shaken right and left along with caregivers' movement, which would brought client's unpleasantness. The trained caregivers moved smoothly. By that, the trained caregivers' help could make the client comfortable, and they were able also to move easily because it shortens the total length of the COG trajectories of the client.

There is one other thing that is important for trained caregivers' characteristics. The trained caregivers could show smooth trajectories repeatedly. From this consequence one may say that the brain will learn internal model of this motion's operation according as skill. In this paper, the trained caregivers' characteristics were extracted by comparing them with unskilled caregivers. Some of the characteristics were smooth trajectories and bell shaped velocities. While having these factors, the trained caregivers would be able to move automatically, in a manner.

In the future study, the results obtained in this study would be discussed with another care-giving motion. It may be possible to shorten the period during which unskilled caregivers acquire skills if unskilled caregivers observe and study the care-giving motions of trained caregivers.

Conclusion

In this study, we compared the care-giving motion of trained caregivers and unskilled caregivers.
The care-giving motion of trained caregivers had the following characteristics:
(1) the COG trajectory showed good coincidence among three trials, (2) the COG trajectory showed smoother curve than that of unskilled caregivers', (3) in the vertical direction, the COG moved at lower position than clients' (4) the COG velocity curve had a single peak, and the change in COG acceleration was small. It was assumed that these characteristics led trainee to skilled caregiver.

References

[1] UNO, Y., KAWATO, M., SUZUKI. R., (1989) : 'Formation and control of optimal trajectory in human multijoint armmovement—minimum torque-change model.' Biol.Cybern,61, pp 89-101

[2] FLASH, T., HOGAN, N., (1985): 'The coordination of arm movements: an experimentally confirmed mathematical model', J. Neurosci.,**5,** pp. 1688-1703

[3] UNO, Y., (2001): 'A computational model of motor skill', Brain Science, **23** , pp 561-568

[4] NIANFENG Y., MING Z., CHANGHUA H., DEWEN J., (2002): 'Synergic analysis of upper limb target-reaching movements', J Biomechanics **35**, pp 739-746

[5] RANDALL F., NAKANO E., IMAMIZU H., OSU R., YOSHIOKA T., KAWATO M., (1999): 'Composition and Decomposition of Internal Models in Motor Learning under Altered Kinematics and Dynamics Environments', J. Neuroscience **19**, RC34

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