Nonsignificant survival improvement in patient outcome was observed between PCS 95-97 and PCS 99-01. The current PCS has limitations in terms of outcome analysis because of a short follow-up period, significant variations in follow-up information according to institutional stratification (4, 17), and difficulties in outcome survey. One of the ultimate goals of the PCS is to determine how structure and processes of radiation therapy affect patient outcomes, including local control, survival, and quality of life. However, since 2006, personal information is strictly protected by law and outcome surveys are difficult to perform in Japan, even for patients with cancer. Cancer is not yet a reportable disease in Japan. Currently, limitations in data accumulation concerning patient outcomes in this type of survey encouraged us to develop new health care data collection systems and linkages among systems that make systematic recording and analysis of structure/process and outcome data part of routine quality monitoring (Japanese National Cancer Database, funded by the Ministry of Health, Labor, and Welfare Japan).

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A Three-Year-Follow-up study on the Change in Physical and Mental Functions of the Aged by the Level of ADL

Evaluation of Data from the Japanese Elderly Care Insurance Certification of Long-term Care Need

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Abstract

Using the value in which the physical and mental condition of elderly persons was converted into the amount of care required time, this paper estimates the average change of physical and mental functions according to the subject's sex and independence level of primary ADL (Activities of Daily Living) over a span of 3 years. The following comparative examination was also carried out: 1) Over a span of 3 years, how did the physical and mental functions of the elderly change? 2) Of the function items, which parts showed a change in function as time passed? 3) Was there any difference in terms of sex? 4) Was there an influence of the care service benefits from Long Term-care Insurance System on functional recovery?

In Higashi-Osaka City, from October 1999 to March 2002, of the 20,393 elderly persons aged 65 years old and above who were administered a visit assessment to determine the level of care required, 10,812 persons who had been visited 3 or more times at intervals of 6 months to 1 year and had had data on their physical and mental conditions continuously obtained from them, were used as subjects.

A "Multilevel Model Analysis" was conducted based on the ADL from the first visit which was divided into 1) almost independent, almost no need for nursing care (low-grade), 2) can lead an independent life if appropriate care is given (middle-grade), 3) unable to lead a normal day-to-day life without complete nursing care (severe-grade). For the basic model, the response variable was the hours spent for care required time, level 1 (i) was across multiple visit

assessment occasions, level 2 (j) was multiple occasions nested within individuals, and the response variable was age at initial visit assessment and years from initial visit assessment (elapsed time).

The prolongation of care required time during the 3 years was calculated at; low-grade male 19.3, middle-grade male 17.6, severe-grade male 2.6, low-grade female 15.2, middle-grade female 16.7, severe-grade female 2.2. The functions that changed over time were those asked in "complex movement" and "the physical hygienics field" items in the survey. These items showed a decrease in function thus increasing the level of required care.

During 3 years the elderly care required time was prolongated. In low-grade and middle-grade, the use of nursing-care service did not prevent worsening of the care required level. In severe-grade an improvement was seen in the nursing-care condition. This may be due to the quantity of care provided. In examining the relationship of the care service and the care condition, it is necessary to look into the kind and quantity of severe-grade service that was used.

Introduction

Aging population and securement of elderly care are common issues faced by developed countries. There is a widened recognition of responding to the problem of elderly care as part of life security for both senior citizens and citizens in active service. Since the year 1995 in Germany and 2000 in Japan, nursing-care has been provided by social insurance. Starting from 2008 it will also be provided by social insurance in Korea. For social insurance, to calculate the insurance cost (fee/premium), an estimate of the care service quantity that the elderly needs is required. To minimize discrepancies (excess or deficit) of the estimate, it is necessary to determine the elderly population with age-related physical and mental changes over time. However, in Japan, as well as other countries, there are only a few longitudinal studies about aging with a sufficient number of samples.

We tried to trace the changes in physical and mental functions of the elderly over a 3 year period, using results of visit assessment data collected to determine the level of care needed in receiving the Japanese elderly care insurance benefits. In this study, in Higashi-Osaka City between October 1999 to March 2002, data was obtained from 20,393 elderly persons aged 65 years old and above who were administered a visit assessment to determine the level of care required. Then out of those above, 10,812 persons who had been repeatedly surveyed 3 or more times at intervals of 6 months to 1 year and had had data on their physical and mental conditions continuously obtained from them, were extracted. Using the value in which the physical and mental condition of the elderly persons was converted into the amount of care required time, the data was grouped by sex and divided into the primary 3 conditions: a) almost independent having little need for nursing care, b) able to lead an independent life if appropriate care is given, and c) unable to lead a normal day-to-day life without complete nursing care. The trend of average change of physical and mental functions of each group was then plotted. A comparative examination of the following was also conducted: 1) Over a span of 3 years, how did the physical and mental functions of the elderly change? 2) Of the function items, which parts showed a change in function as time passed? 3) Was there any difference in terms of sex? 4) Was there an influence of the care service benefits from Long Term-care Insurance System on functional recovery? (Whether they can be evaluated as effective for functional recovery which is one of the principles of the system.)

Data and Method

1. Japanese Long-term Care Insurance System

In Japan, the public Long-term Care Insurance (LTCI) System has been enforced since April 2000. There is also public elderly care insurance in Germany, but the salient feature of the Japanese LTCI is that it includes elderly persons with a low level of needed care as beneficiaries of the insurance system. The reason is that for elderly persons requiring mild care, the possibility of functional recovery is high thereby providing benefits may prevent their condition from becoming worse.

There are 2 categories of insured persons, category 1 are persons aged 65 or over and category 2 are persons aged 40 to 64. Category 1 insured persons can receive elderly care insurance payments if they are in a condition that requires care for any reason, but category 2 insured persons can only receive care insurance if they require care because of a condition caused by a limited number of reasons (up to year 2006 there were 15 disease categories, which later increased to 16 diseases). To be able to receive care insurance benefits, first, the applicant must apply to the municipality he/she resides in. The municipality that receives the application, in principle would conduct visit

Table 1 The government-certified disability index and maximum monthly coverage for services under the LTC insurance scheme

GCDI score	Care-demand-time (min)	Severity of impairment	Maximum coverage of services/month
Independence	less than 25		not eligible
0	over 25 less than 30	Frailty, slight impairment	61,500 yen (560 US dollars)
1	over 30 less than 50	ADL difficulties	276,976 yen (2,518 US dollars)
2	over 50 less than 70	Moderate impairment	296,976 yen (2,700 US dollars)
3	over 70 less than 90	Severe impairment	318,816 yen (2,898 US dollars)
4	over 90 less than 110	Severe impairment with special needs	340,968 yen (3,010 US dollars)
5	over 110	Bedridden with special needs	362,808 yen (3,298 US dollars)

Exchange rate used: US dollar =110 yen.
Source: Ministry of Labor, Health and Welfare

assessments to the applicant's home to determine the level of viability of activities of daily living (ADL) and level of dementia of the applicant. A care manager commissioned by the municipality conducts the investigation. The care manager must have medical and welfare expertise and be certified after taking the qualifying exam upon completing 5 or more years of hands-on experience.

As a result of the investigation, care is provided according to the determined level (6 levels). At this stage, if the decision is made that care is not necessary, insurance benefits cannot be received. The certification of the level of care required is in principle valid for 6 months. One must apply again after half a year and must be administered the visit assessment to continuously receive the insurance benefits. However, the next application period may be extended to one year if it is acknowledged that there is no substantial change in the condition. For insurance benefits for each level of care required, there is a limit to the amount the person can receive and he/she can freely select which service to receive within that limit. (See Table1)

2. Care Required Level and Care Required Time

The investigation that measures ADL and level of dementia, is conducted based on a Japanese survey form consisting of 7 categories with a total of 85 items. This same form is used throughout Japan. In April 2003, minor changes were made and currently the survey form consists of 7 categories with a total of 79 items.

The conditions of the applicants obtained from the survey forms are scored by a computer. The Ministry of Health, Labor and Welfare in Japan developed a model in 1996, which can estimate the time of care based on the survey of mental and physical conditions. The method used to collect the data is a 1-minute time and motion study. The 1-minute time and motion study was conducted involving approximately 3,400 elderly persons admitted in a nursing home, using a process that records the mental and physical conditions of a person and the kind of care service offered per minute within 48 hours. As a result, the 73 items of the survey result of each subject's physical and mental conditions and the amount of time of care service offered for each of the 312 kinds of nursing care services became evident.

Theoretically, if an elderly person has exactly the same mental and physical conditions as one of the elderly persons who was a subject of the time and motion study, by searching for that data from the 3,400 people, the amount of time of nursing-care service to be offered to the person can be measured. However, since the physical and mental conditions of elderly persons are extremely diverse, that kind of perfect match does not occur. Consequently, a statistical technique called tree model was introduced. It is a method that estimates the time of care service to be offered by searching for the group that is similar to the mental and physical condition of the elderly person. In the tree model branch, to prevent the result from differing greatly from the value of the survey item, only similar trends are checked among the survey items. In other words importance is placed on the total score of the survey items with high relativity and are divided into 7 groups. This is called the middle assessment score (MAS). The 7 groups of MAS are "paralysis and contracture", "simple movement", "complex movement", "food intake", "physical hygienics", "commu nication","symptoms of dementia", and each are indicated by a value within the range of 0 to 1000. MAS shows that as the numerical value rises the function is maintained and it also becomes an index that evaluates the condition of the applicant's function according to the group. The survey items that comprise those groups are shown in Table 2.

By tracing the tree diagram using a certain physical and mental condition and a certain field, the required time for care of each field is also traceable; the total/overall time becomes what is known as the care required time or CRT. Here, CRT as a scale which shows the time of care, entails the assumption that under the condition that there are 2 people having exactly the same mental and physical condition then the difference in their socio-economic status (living with family or living alone, living in a barrier-free housing or not, caregiver is a family member or not) will be overlooked and the CRT for A would also be the CRT for B. However, CRT is time for the sake of simplicity/convenience, it does not correspond to the actual time needed for care itself. CRT is indicated by the value within the range of 0 to 216, and as the numerical value rises it means that there is a deterioration in ADL and level of dementia.

Functional Independence Measure (FIM) and Barthel Index are used worldwide as a standard index for ADL. According to the report of Sakamoto, et al. (2000), although the examination of the care required level as compared to these indexes is not enough, in the example given where care required level and FIM score were applied to the same subject the status of the following support required were; care level 1 is FIM24.5±7.7, care level 2 is FIM34.6±14.1, care level 3 is FIM55.2±19.6, care level 4 is FIM82.4±21.7 and care level 5 is FIM102.1±11.0.

3. Sample Selection and Analysis

Higashi-Osaka city, with a population of approximately 510,000 people, is a government-decreed major city in Osaka prefecture, the second largest city in Japan. Approximately 101,500 of the total population are aged 65 years old and above, an aging rate of 20% (2007). When the LTCI System started, from October 1999 to March

Table 2 The investigation item for measurement of MAS group

G1	paralysis and contracture	paralysis (left arm)
		paralysis (right arm)
		paralysis (left leg)
		paralysis (right leg)
		paralysis (other)
		contracture (shoulder joint)
		contracture (cubital joint)
		contracture (hip joint)
		contracture (ankle)
		contracture (other)
G2	simple movement	rolling over
		raising oneself up
		maintaining a sitting position (with both feet)
		maintaining a sitting position
		maintaining a standing position (with both feet)
		walking
		moving oneself to another place
G3	complex movement	raising oneself up
		maintaining a standing position (on one foot)
		getting into or out of the bathtub
		washing oneself
G4	food intake	decubitus
		dermatopathia
		lifting the arm to breast level
		swallowing
		micturition desire
		defecation desire
		cleaning up after micturition
		cleaning up after defecation
		dietary intake
G5	physical hygienics	cleansing the mouth
		washing the face
		caring for nails
		fastening and unfastening buttons
		putting on or taking off one's coat
		putting on or taking off one's pants
		pulling on or pulling off one's stockings
		cleaning the living area
		taking medicine
		budget management
		memory loss
		indifference
G6	communication	eyesight
		hearing
		communication
		dealing with assignments
		understanding daily routines
		understanding dates of birth
		understanding seasons
		understanding places
G7	symptom of dementia	delusion of persecution
		fabrication
		hallucination
		emotional instability
		day and night are reversed
		verbal and/or physical aggression
		repetition when speaking
		screaming and yelling
		refusing nursing care
		poriomania
		lacking repose
		becoming disoriented
		desire for going outside alone
		collects items
		failure to put out fires (cigarettes, cooking stoves etc)
		destructs object or clothes
		filthy behavior
		pica
		inappropriate sexual behaviour
		15 sorts of medical practice

Table 3 Models compared

	dependent variable	independent variable						
	Y	intercept	age	age sq	age/10	age/10 sq	year	year sq
Model 1	CRT	R	F				F	
Model 2	CRT	R	F				R	
Model 3	CRT	R	F				R	R
Model 4	CRT	R	F	F			F	
Model 5	CRT	R	F	F			R	R
Model 6	CRT	R	F	F			R	R
Model 7	CRT	R			F	F	R	R
Model 8	log CRT	R			F		F	
Model 9	log CRT	R			F		R	
Model 10	log CRT	R			F		R	R
Model 11	log CRT	R			F	F	F	
Model 12	log CRT	R			F	F	R	
Model 13	log CRT	R			F	F	R	R

R: random effect

F: fixed effect

2002 within a 3-year period there were 20,393 persons who were 65 years and above who were administered the visit assessment one or more times. Of the above, 10,812 people were continuously visited 3 or more times.

To be able to track the changes in 3 years from the initial condition of required care, in the analysis persons who were administered the visit assessment 3 or more times were used as subjects. The CRT of the subjects from the initial visit were divided into 3 grades; unqualified assistance and care level 1: low-grade, care level 2 and 3: middle-grade and care level 4 and 5: severe-grade. They were then grouped according to sex. A multilevel analysis was done on each grade and according to sex.

Multilevel analysis is a methodology for the analysis of data with complex patterns of variability, with a focus on nested sources of variability: e.g., longitudinal measurements of subjects. In the analysis of such data, it usually is illuminating to take account of the variability associated with each level of nesting. The multilevel regression model examines individual changes at two levels. For the basic model, the response variable was the hours spent for care required time, level 1 (i) was across multiple visit assessment occasions, level 2 (j) was multiple occasions nested within individuals, the response variable was age at initial visit assessment and years from initial visit assessment (elapsed time). The age was selected from a combination of age setting, the square of age, age/10 and the square of age/10 and then a fixed effect was set. The elapsed number of years since the initial visit assessment was selected from the combination of number of years and the square of number of years and was examined comparatively by random effect and fixed effect. The intercept was set as random effect. 13 models in total were set and the degree of compatibility was evaluated using the Akaike Information Criterion (AIC) and the models with the highest degree of compatibility were selected. (See Table 3)

As for the trend of CRT, the age from the initial visit was estimated according to 10-year age groups starting from 65 years old. At the same time, the model was set with MAS as response variable.

The software used was Mlwin (Multilevel Models Project Institute of Education) version 1.10.0007.

4. Ethical Consideration Regarding the Data

In this study, the provisions of individual data on the certification for the LTCI need and care benefits statement of account were received from Higashi Osaka City. In the data provisions, from the perspective of personal information protection, identification of an individual was made impossible by taking the necessary measures of deleting the individual's name and address and randomly converting their insurance number into personal ID numbers. Furthermore, close attention was given to data management to prevent the information from leaking to a third party.

Result

Visit assessment frequency and number of applicants according to group and sex was:

Low-grade male=5,793 (1,302 people) age range from 64.63 to 99.25 (mean 79.24, sd7.50),

Middle-grade male=4,612 (1,020 people) age range from 64.73 to 99.88 (mean 78.56, sd7.82),

Severe-grade male=2,480 (552 people) age range from 64.89 to 103.47 (mean 77.61, sd7.73),

Low-grade female=18,827 (4,046 people) age range from64.72 to 100.90 (mean 80.26, sd6.84),

Middle-grade female=12,418 (2,604 people) age range from 64.57 to 103.04 (mean 81.79, sd7.50),

Severe-grade female=5,937 (1,288 people) age range from 64.73 to 103.53 (mean 82.60, sd7.63)

The selected models with the highest degree of compatibility in each grade were the following:

Low-grade male:

$logCRT_{ij} = 5.729–0.560(age/10)_j+0.035(age/10)^2_j+0.302year_{ij}–0.053year^2_{ij}$

Middle-grade male:

$CRT_{ij} = 139.616–19.009(age/10)_j+1.230(age/10)^2_j+4.860year_{ij}+0.340year^2_{ij}$

Severe-grade male:

$CRT_{ij} = 123.494–0.231age_j–14.008year_{ij}+4.963year^2_{ij}$

Low-grade female:

$logCRT_{ij} = 4.826–0.391(age/10)_j+0.028(age/10)^2_j+0.270year_{ij}–0.047year^2_{ij}$

Middle–grade female:

$CRT_{ij} = 158.325–25.136(age/10)_j+1.679(age/10)^2_j+1.681year_{ij}+1.300year^2_{ij}$

Severe-grade female:

$logCRT_{ij} = 4.677–0.004 (age/10)_j–0.134year_{ij}+0.046year^2_{ij}$

Details of the coefficient are shown in Table 4.

In the derived models, the result of the estimated change in CRT at 65, 75, 85, 95 and 105 years old as age at the time of the initial visit is shown in Figure 1. The prolongation of care required time during 3 years is calculated at; low-grade male 19.3, middle-grade male 17.6, severe-grade male 2.6, low-grade female 15.2, middle-grade female 16.7, severe-grade female 2.2.

The model wherein the change in score was estimated with the CRT method and at the same time MAS as response variables are selected below:

Low-grade male:

G1 $MAS=614.112+3.122(age/10)_j–27.668(age/10)^2_j–63.455year_{ij}+9.680year^2_{ij}$

G2 $MAS=–128.676+27.245age_j–0.176age^2_j–75.883year_{ij}+5.184year^2_{ij}$

G3 $MAS=–924.502+436.786(age/10)_j–28.500(age/10)^2_j–133.336year_{ij}+20.756year^2_{ij}$

G4 $MAS=970.804–0.044age_j–46.367year_{ij}–0.500year^2_{ij}$

G5 $MAS=144.239+170.523(age/10)_j–10.363(age/10)^2_j–129.962year_{ij}+15.787year^2_{ij}$

G6 $MAS=585.247+98.987(age/10)_j–6.800(age/10)^2_j–43.910year_{ij}+3.091year^2_{ij}$

G7 $MAS=1022.641–0.993age_j–19.034year_{ij}+3.334year^2_{ij}$

Middle-grade male:

G1 $MAS=–1748.431+55.237age_j–0.294age^2_j–70.875year_{ij}+7.193year^2_{ij}$

G2 $MAS=650.912+1.084age_j–64.390year_{ij}–3.318year^2_{ij}$

G3 $MAS=454.036–0.316age_j–37.362year_{ij}–3.862year^2_{ij}$

G4 $MAS=947.779–1.088age_j–52.942year_{ij}–1.885year^2_{ij}$

G5 $MAS=–311.276+243.830(age/10)_j–16.962(age/10)^2_j–79.585year_{ij}+4.409year^2_{ij}$

G6 $MAS=1142.487–3.478age_j–45.685year_{ij}–2.841year^2_{ij}$

G7 $MAS=1015.258–1.273age_j–3.274year_{ij}–2.131year^2_{ij}$

Table 4 Coefficient and the standard error which were estimated

male

	low-grade			middle-grade			severe-grade	
	coeff.	s.e.		coeff.	s.e.		coeff.	s.e.
	y=log CRT			y=CRT			y=CRT	
intercept β_0	5.729	0.643	intercept β_0	139.616	40.536	intercept β_0	160.875	56.628
initial age/10 β_1	-0.560	0.163	initial age/10 β_1	-19.009	10.304	initial age/10 β_1	-11.869	14.453
initial age/10sq β_2	0.035	0.010	initial age/10sq β_2	1.230	0.650	initial age/10sq β_2	0.609	0.916
year β_2	0.302	0.014	year β_2	4.860	0.933	year β_2	-14.019	1.448
yearsq β_3	-0.053	0.005	yearsq β_3	0.340	0.340	yearsq β_3	4.970	0.537
δ^2_{e0}	0.059	0.002	δ^2_{e0}	188.399	5.621	δ^2_{e0}	217.759	8.923
δ^2_{u0}	0.007	0.002	δ^2_{u0}	27.874	8.878	δ^2_{u0}	49.835	15.129
δ^2_{u2}	0.078	0.011	δ^2_{u2}	317.348	40.289	δ^2_{u2}	492.909	71.462
δ^2_{u3}	0.007	0.001	δ^2_{u3}	27.343	4.754	δ^2_{u3}	57.100	9.153
δ_{u20}	0.047	0.004	δ_{u20}	162.141	13.634	δ_{u20}	160.018	23.775
δ_{u30}	-0.015	0.001	δ_{u30}	-49.834	4.722	δ_{u30}	-55.388	8.364
δ_{u32}	-0.020	0.004	δ_{u32}	-85.640	13.463	δ_{u32}	-163.119	25.035

female

	low-grade			middle-grade			severe-grade	
	coeff.	s.e.		coeff.	s.e.		coeff.	s.e.
	y=log CRT			y=CRT			y=CRT	
intercept β_0	4.826	0.389	intercept β_0	158.325	25.922	intercept β_0	190.191	37.444
initial age/10 β_1	-0.391	0.098	initial age/10 β_1	-25.136	6.425	initial age/10 β_1	-20.779	9.213
initial age/10sq β_2	0.028	0.006	initial age/10sq β_2	1.679	0.396	initial age/10sq β_2	1.253	0.564
year β_2	0.270	0.008	year β_2	1.681	0.583	year β_2	-10.460	0.842
yearsq β_3	-0.047	0.003	yearsq β_3	1.300	0.209	yearsq β_3	3.729	0.301
δ^2_{e0}	0.061	0.001	δ^2_{e0}	190.294	3.427	δ^2_{e0}	185.223	4.888
δ^2_{u0}	0.007	0.001	δ^2_{u0}	30.020	5.578	δ^2_{u0}	64.221	9.188
δ^2_{u2}	0.072	0.006	δ^2_{u2}	340.332	25.130	δ^2_{u2}	376.089	37.085
δ^2_{u3}	0.007	0.001	δ^2_{u3}	31.167	2.953	δ^2_{u3}	38.559	4.440
δ_{u20}	0.043	0.002	δ_{u20}	177.735	8.462	δ_{u20}	126.060	13.427
δ_{u30}	-0.014	0.001	δ_{u30}	-55.554	2.898	δ_{u30}	-42.185	4.578
δ_{u32}	-0.019	0.002	δ_{u32}	-94.708	8.367	δ_{u32}	-117.457	12.569

Severe-grade male:

G1 $MAS=-1748.431+55.237age_j-0.294age^2_j-70.875year_{ij}+7.193year^2_{ij}$

G2 $MAS=167.626+2.977age_j+15.356year_{ij}-21.799year^2_{ij}$

G3 $MAS=167.626+2.977age_j+15.356year_{ij}-21.799year^2_{ij}$

G4 $MAS=611.767-0.137age_j+12.326year_{ij}-17.873year^2_{ij}$

G5 $MAS=153.189+0.343age_j+60.428year_{ij}-24.166year^2_{ij}$

G6 $MAS=964.094-3.155age_j-40.555year_{ij}+0/706year^2_{ij}$

G7 $MAS=1023.072-1.721age_j+19.660year_{ij}-2.503year^2_{ij}$

Low-grade female:

G1 $MAS=-1138+476.336age_j-43.230year_{ij}$

G2 $MAS=1011.170-1.561age_j-58.542year_{ij}$

G3 $MAS=1060.233-4.685age_j-71.501year_{ij}$

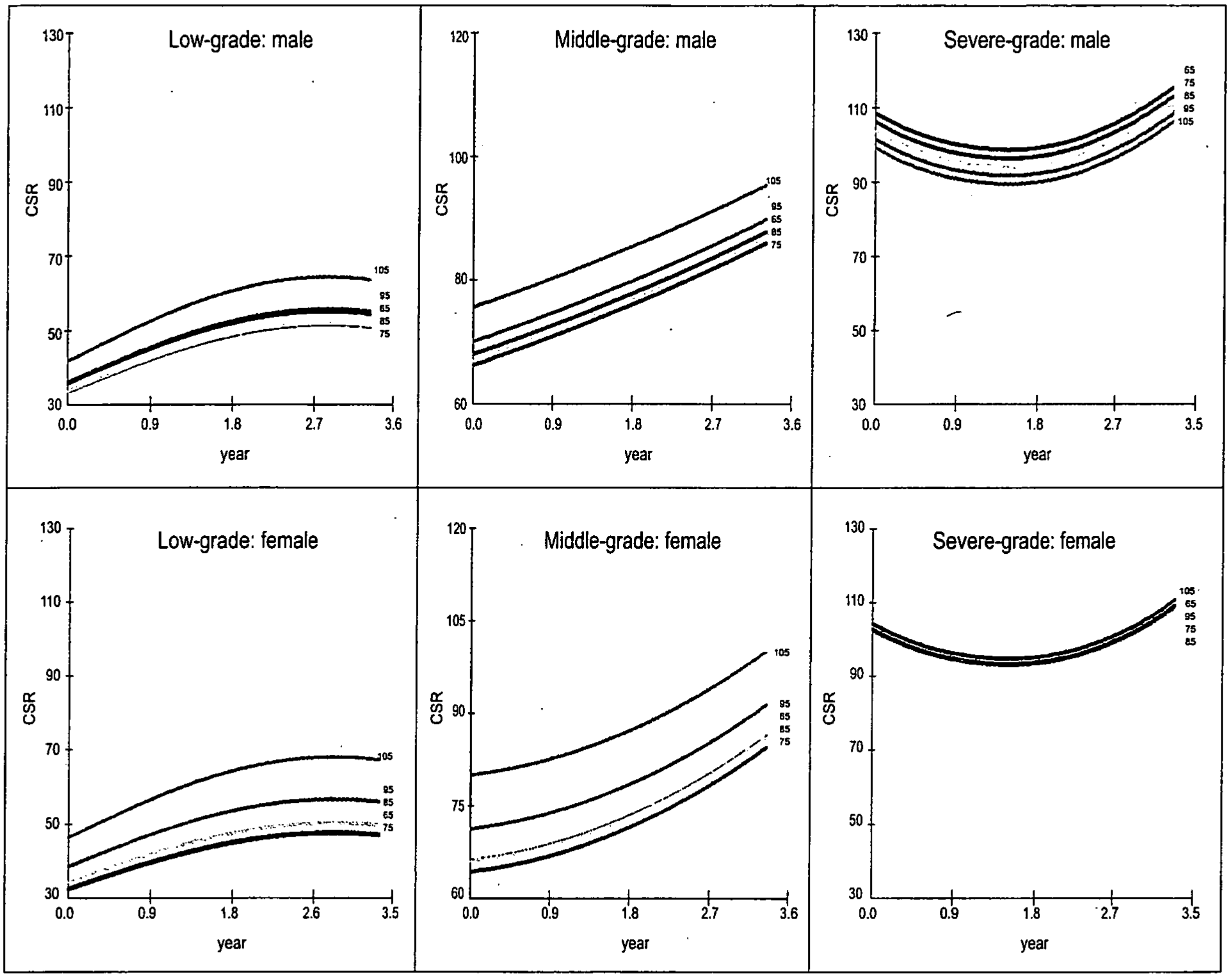
G4 $MAS=1047.941-0.917age_j-39.140year_{ij}$

G5 $MAS=1132.918-3.513age_j-82.965year_{ij}$

G6 $MAS=1394.066-6.936age_j-38.209year_{ij}$

G7 $MAS=1084.747-1.812age_j-7.983year_{ij}$

Figure 1 Change of the CRT in three years



Middle-grade female:

G1 $MAS=-1121.640+420.592(age/10)_j-22.700(age/10)^2_j-76.329year_{ij}+8.268year^2_{ij}$

G2 $MAS=-912.963+424.513(age/10)_j-27.416(age/10)^2_j-46.188year_{ij}-8.802year^2_{ij}$

G3 $MAS=-1240.288+446.129(age/10)_j-29.695(age/10)2j-8.390year_{ij}-12.852year^2_{ij}$

G4 $MAS=-176.115+208.079(age/10)_j-14.999(age/10)^2_j-48.719year_{ij}-4.355year^2_{ij}$

G5 $MAS=1418.945-7.101agej-78.373year_i$

G6 $MAS=-99.478+253.297(age/10)_j-19.885(age/10)^2_j-42.467year_{ij}+1.820year^2_{ij}$

G7 $MAS=1128.933-2.950agej+9.364year_{ij}-1.429year^2_{ij}$

Severe-grade female:

G1 $MAS=-1599.863+48.824age_j-0.267age^2_j-97.520year_{ij}+14.694year^2_j$

G2 $MAS=-1088.023+35.861age_j-0.226age^2_j-8.457year_{ij}-15.774year^2_{ij}$

G3 $MAS=170.763-0.759age_j+42.632year_{ij}-18.367year^2_{ij}$

G4 $MAS=813.506-3.269age_j-0.559year_{ij}-12.344year^2_{ij}$

G5 $MAS=298.656-1.675age_j+49.822year_{ij}-20.217year^2_{ij}$

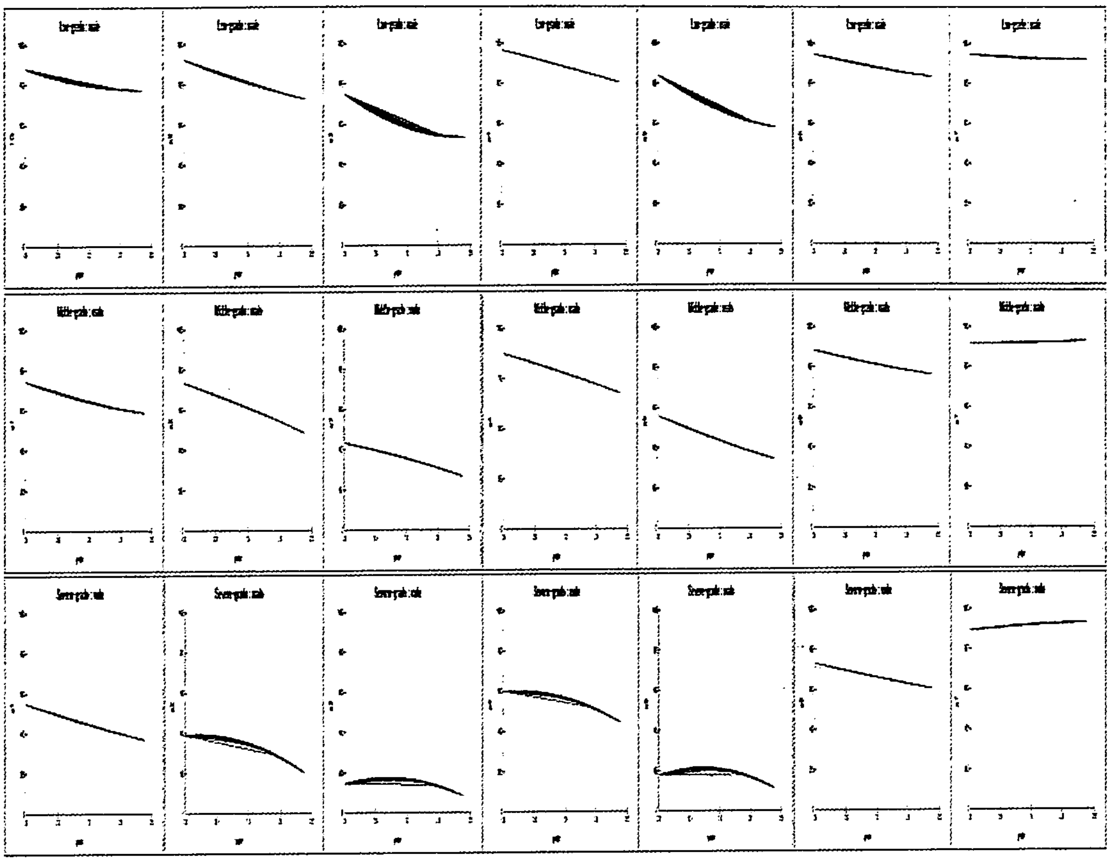
G6 $MAS=1128.998-5.966age_j-35.552year_{ij}-4.412year^2_{ij}$

G7 $MAS=1008.596-1.542age_j+25.570year_{ij}-4.538year^2_{ij}$

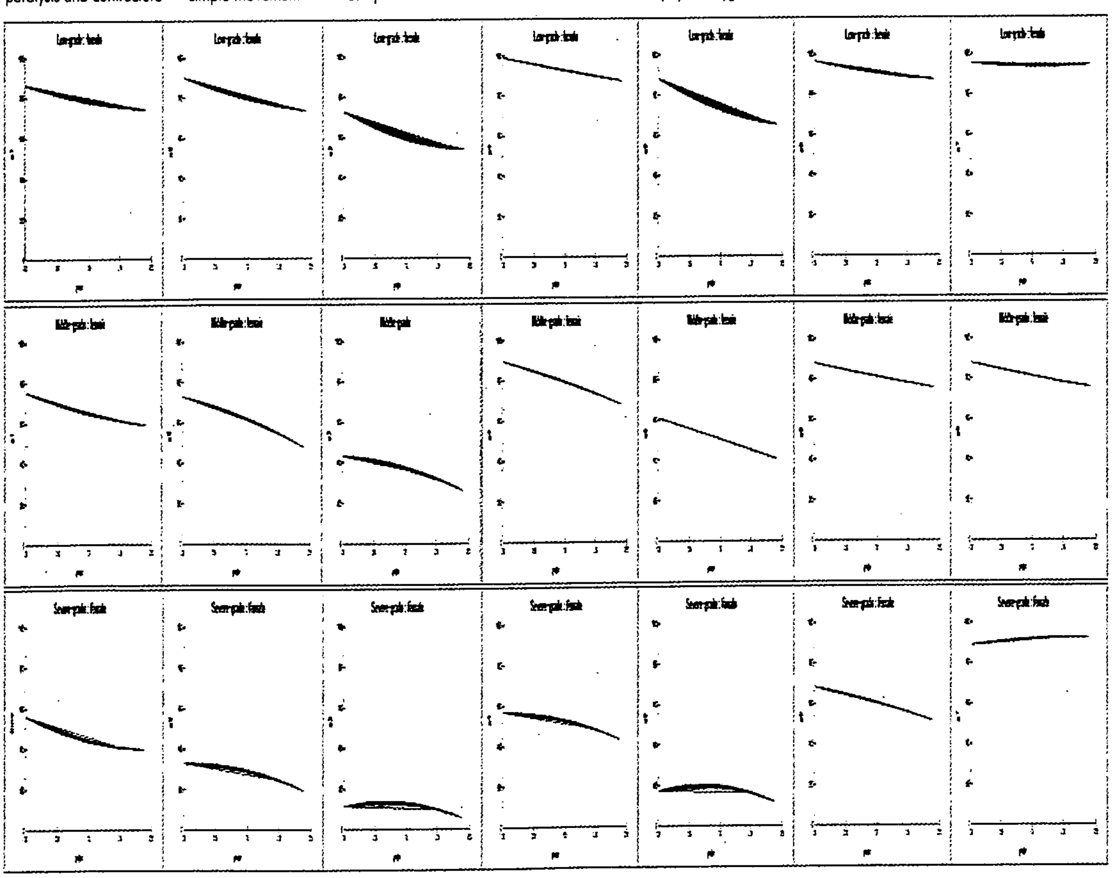
In the derived model, the result of the estimated change in MAS temporarily set at 75 years old as age at the time of the initial visit is shown in Figure 2.

Figure 2 Change of the MAS in three years: estimated at 75 years old

paralysis and contracture | simple movement | complex movement | food intake | physical hygienics | communication | symptoms of dementia



paralysis and contracture | simple movement | complex movement | food intake | physical hygienics | communication | symptoms of dementia



Discussion

If the natural history of elderly persons is to be traced, it can be said that there are 2 ways of dying; the first way is aging from a healthy condition, then death from illness, and the second way is aging from a healthy condition, then developing a disorder from illness and finally death from senility or illness. Whichever way, elderly persons are entitled to receive care insurance from the stage before an illness or disorder occurs. Many elderly persons tend to receive a visit assessment only after realizing the need for care due to a disorder and starting to use the LTCI. However, the Japanese LTCI having the objective of preventing one from reaching the condition of requiring care, provides the service even before reaching this condition. Also, several elderly persons have further developed creative ways of using the insurance. The level of care provided is decided only after receiving a visit assessment. In order to avoid the waiting time period until the service is provided, one must receive certification for low level of care although he/she can really live independently without using the service. In that way, when the need for care service arises he/she is prepared to immediately acquire the service. As a result, the LTCI visit assessment data is valuable data that can track the elderly person's aging process from the almost healthy condition until the disorder gradually worsens.

During 3 years the elderly care required time was prolongated. For both sexes in low-grade and middle-grade the average extension in 3 years was approximately 17 minutes.

The care required level goes up one level for every 20 minute increase in CRT, therefore, change in condition over the 3-year period would also affect the cost of LTCI. The Japan Medical Association Research Institute and the Shimane Prefecture Health and Welfare Department Elderly Welfare Unit (2003) published a research that focuses on the change in condition of care needed. This is a follow-up research of certification of LTC need done on 3 insured persons in Shimane prefecture from 2000 to 2002 every October of each year. In this report, it was pointed out that the deterioration rate of the person certified as "assistance required," especially the deterioration rate of elderly person with dementia is very high. This research also recognized that the care time needed for elderly persons with low-grade care became longer but at the same time recognized that to a similar extent the middle-grade elderly care time also increased.

In Higashi-Osaka City, Osaka prefecture's government-decreed major city, and Shimane prefecture, there may be a big difference in the living environment, the medical care welfare service maintenance situation and illnesses that require care. In the future it will be necessary to verify a regional difference in the deterioration in the conditions that require care.

It may be said that during 3 years since the inauguration of the system, the objective of the LTCI of preventing people from reaching conditions that need care has not yet been fully achieved. In order to improve the preventive benefits of the LTCI for the elderly persons certified as low-grade, since the year 2006, inductive system reforms were carried out so that elderly persons would become positively receptive to the following preventive purposed services, namely, limiting excessive residential care benefits that would prevent the person from performing tasks himself/ herself. Oral care, nutrition counseling and strength training were also introduced to prevent the deterioration of care conditions. It is clear in many researches that these menus work effectively on the general conditions of elderly persons. Most of all it is expected to prevent respiratory infection, falling, and other underlying causes that would make them bedridden. However, changes which are presumed to have caused the person to become bedridden, that is, those that have shown 20 minutes or more extension in CRT were low-grade male 2%, female 2%, middle-grade male 2.16% and female 1.92 %. Also conditions which showed changes that raised the care required level by 1 rank and showed more than 10 minutes but less than 20 minutes extension in CRT, even though the person was not bedridden, were low-grade male 19.20%, female 16.93%, middle-grade male 19.71% and female 18.16%. Therefore, although a future verification is being anticipated, it is believed that expansion of preventive benefits as a result of the revised LTCI only has a small impact on improving care levels. However, these menus for preventive purposes will influence the improvement or maintenance of the general condition. These menus are encouraged to be used not only by low-grade elderly persons, but as was seen in the result of this study, it is considered that even for middle-grade elderly persons additional care preventive intervention is also necessary.

It can be said that the aging of most elderly persons progresses gradually. MAS analysis was done to be able to infer what kind of function changes emerge in a gradual aging development. In the period of 3 years the MAS function of each field declined.

Throughout the 3 years functional improvement was only seen for symptoms of dementia in severe-grade. For symptoms of dementia, the actions commonly-noted in dementia cases were checked for. It was noted that the differences in care required level tended to be due to scores for "complex movement" and "physical hygienics". Additionally, in the shift from middle-grade to severe-grade, a decline in the scores of "simple movement" and "food intake" were seen. From these results, it can be said that if the need for care is to lessened, it is necessary to improve the scores of "simple movement" and "physical hygienics". Also, in order that these scored do not decrease, it is also necessary to use occupational therapy and proper welfare equipment.

It is in low-grade that a difference between the sexes was seen in the change in CRT; the extension of CRT for males was 4 minutes longer than that of the females. Locating the specific MAS field of this gap is difficult. For "simple movement", "food intake" and "communication" a tendency was seen for the males' score to have a little more decline than the females'.

In severe-grade there was almost no extension in CRT. A very low level of ADL independence and a strong degree of dementia characterizes the conditions of severe-grade. Since the measurement ceiling of CRT is 216 minutes, it does impose a limit on the ceiling, and if the condition deteriorates it is possible also to measure the value of this. It is presumed that as long as the care required level is determined, subjects of severe-grade can immediately start using the care service because they require a lot of care support. The CRT measured during the initial research was shortened to 1.5 years and after that tends to rise in a slow curve. The shortened range of CRT was about ten minutes. In the trend of MAS, "simple movement" is half a year, "food intake" is 1 year, "complex movement" and "physical hygienics" is 1.5 years period of score improvement was confirmed.

From the view of clinical depression, it is said that when the severe-grade condition is reached, the improvement of the condition from that point becomes difficult. Given this factor, it was ascertained that the improvement of care condition that was confirmed in this study influences the decision to discontinue the service. In severe-grade, it is expected that the general condition is bad and due to the deterioration of illness, the benefits of the care service is stopped by the LTCI. There are cases where the treatment is transferred to medical insurance. There are also cases of death. Due to these reasons, it is possible that if a large number of subjects do not continuously receive the visit assessment, the number of subjects who show deterioration will decrease and show an apparent improvement when the estimate of the average is calculated. As an equivalent to that of the certificates of medical renumeration/ medical bill from the medical insurance, in the LTCI there is the care benefits statement of account. While using the services of the LTCI, the data regarding usage is recorded on the care benefits statement of account. From the care benefits statement of account, from the last certification of long-term care need, in the severe-grade 148 out of the 552 males and 323 out of the 1288 females discontinued the use of the service within the validity period. In the care benefits statement of account, when the service is cancelled, there is a column to input the reason for cancellation. The cancellation reason code is "non-applicable", "hospitalization", "deceased" and "others". "Non-applicable" is cancellation due to the conclusion of the interim measure. That was imposed on the recipient of the services from the previous system before the LTCI system was enforced. "Others" includes cancellation of service without any specific reason, change of residence and so on. Unfortunately, not all cases of cancellation of allocated services are inputted in the cancellation reason code. However, the person in charge of administration of the municipal insurance says that, on the occasion that discontinuity of service is made for severe-grade, even in the case of a missing cancellation reason code, the reason for withdrawal from the insurance is mostly hospitalization and death. Therefore, subjects who allegedly discontinued allocated services due to physical and mental deterioration were assumed to be 140 males (25.36%) and 310 females (24.07%). An estimate was done on the discontinuers using CRT as response variable because both male and female matched model 3 upon selecting the model. The result was, even for the discontinuers, for males after half a year and females after up to 1 year, a decrease by about 5 minutes of CRT was seen. This confirms that not only the survivors of severe-grade are improving. Due to the above reasons, it is possible that the use of care services effectively prevented the deterioration of the person's condition in severe grade.

Conclusion

In 3 years the elderly care required time was prolongated. For both sexes in low-grade and middle-grade the average extension in 3 years was approximately 17 minutes and the care required level moved up one level. In severe-grade there was an extension of approximately 2 minutes in the care required time.

In the change in functions that occurred over time, the questioned functions in the survey item fields of complex movement and physical hygienics declined and the degree of care needed rose.

The functions that are asked for "complex movement" and "physical hygienics" in the survey items decreased so that care required level increased one level when examined with MAS.

The selection of the kind of care service was left to the individual's choice for the period during which the data was collected and service with aggressive/positive functional recovery as an objective was not selected. As a result, in the low-grade and middle-grade, the prevention of worsening of the level of care required was not achieved. However, the effect of the preventive service that was introduced last year contributes to the QOL of the individual though the prediction of care preventive effect as a whole is furtive. Similarly, for severe grade there were no inductive conditions for selecting the kind of care service. Even still, an improvement was seen in the care condition. This may be due to the quantity of care provided. In examining the relationship of the care service and the care condition, it is necessary to look into the kind and quantity of severe-grade service that was used.

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Evaluation Parameters for Care-Giving Motions

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Abstract. Quantitative evaluation parameters for care-giving motions were investigated by analyzing three-dimensional motion data of skilled and unskilled caregivers. Subjects were three skilled caregivers, each of whom had over 12 yrs of clinical experience, and four physical therapy students. We recorded a typical care-giving motion between a caregiver and a care-receiver three times for each caregiver/receiver pair with a 3-D motion analysis system (VICON system, Oxford Metrics, UK). We did time-series analyses to extract performance evaluation parameters from observed indexes such as trajectories, velocities, accelerations of the body's center of gravity (COG), jerk-cost, and impulse. The analyzed motion was lifting a patient lying on a bed into the sitting position. The skilled caregivers' operation times were shorter than those of the unskilled caregivers. The COG trajectories of skilled caregivers showed smoother and better reproducibility over the three trials, and the COG velocity curves showed a high single peak at start up. The jerk-cost and impulse of skilled caregivers were lower than those of unskilled caregivers. We found reproducibility and smoothness of movement to be good evaluation parameters for care-giving motions. The measurement indexes observed in this study should be introduced to improve evaluation of the education of unskilled caregivers.
Key words: Characteristics of the skilled caregiver, 3D motion analysis, Jerk-cost

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INTRODUCTION

Skilled movements, which can be acquired through training and practice, help achieve certain objectives associated with a particular task. It has been demonstrated in several studies[1, 2)] that skilled movements are characteristically smooth. Smoothness of movement has been quantified[1–4)] using the mean squared magnitude of jerk, where jerk is defined as the third order derivative of position. In mathematical terms, to produce the smoothest possible movement, the criterion function, jerk-cost (JC), is defined as

$$JC = \int_0^T \left| \frac{d^3 r}{dt^3} \right|^2 dt, \qquad [1]$$

where T is movement duration and r denotes the position vector.

The original model of maximum smoothness (minimum jerk) was derived for a voluntary human arm movement. When moving a hand between a pair of targets, subjects tend to generate a straight path with single peak, bell-shaped velocity profiles.

Hogan[3)] suggested that the meaning of this trajectory is that the minimization of mean-squared jerk is a mathematical model of one movement objective, the production of smooth, graceful movements. This model is called the minimum jerk model. The model has been used successfully to simulate single-joint planar movement[3, 5, 6], and multi-joint movement[7]. The model has also been used to evaluate motor performance during skill acquisition. Schneider and Zernicke[8] showed that significantly less JC was observed in the slowest hand movements after subjects had practiced the movements. Hreljac[9–11] argued that smoothness of gait can be quantified by evaluating JC and that competitive runners tend to exhibit smoother strides than recreational runners during both running and fast walking. Also, examination of development of reaching movements among human infants showed increasingly rapid decrease of movement jerk with increasing age[12–14].

In Japan, development of human resources is an issue that has become increasingly urgent as the population ages. However, skill parameters as a basis on which to decide how much care-giving motion training should be done have not yet been established. It is generally agreed that the motions of skilled caregivers are typically smooth, and it is hypothesized that the minimum-jerk model applies to care-giving motions. One important difference between care-giving motions and casual movements is that care-giving motions are derived from the interaction of the caregiver and care-receiver, which requires the safety and comfort of both parties.

The purposes of this study were to examine whether JC was an appropriate skill parameter for care-giving motions and to investigate other quantitative evaluation parameters for care-giving motions. In order to investigate the kinetic characteristics of skilled caregivers during the interactive movements of caregiver and care-receiver, we analyzed three-dimensional motion data for skilled and unskilled caregivers.

METHODS

The care-giving subjects were three skilled and four unskilled caregivers. The skilled caregivers were women who each had 12 years or more of experience as a physical or occupational therapist. They were between 153 and 160 cm tall and weighed between 50 and 56 kg. The unskilled subjects were female students in the second year of a physical therapy training course who were

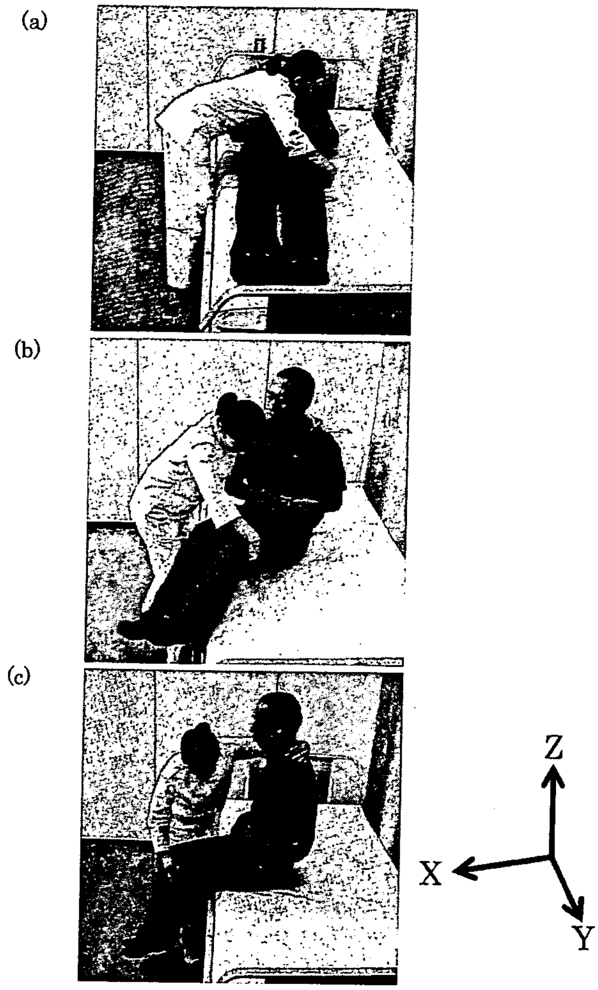

Fig. 1. Care-giving body movement.

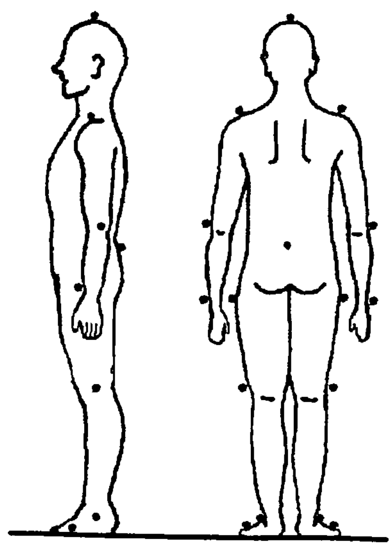
Fig. 2. Marker locations on the body.

Table 1. Comparison of the results in the skilled and unskilled caregivers

	Skilled caregiver	Unskilled caregiver
Operation time	2.86 ± 0.40 (s)	5.03 ± 0.69 (s)
COG trajectory		
Correlation coefficient among three trials per subject	X: 0.988 ± 0.007 Y: 0.960 ± 0.029 Z: 0.952 ± 0.021	X: 0.896 ± 0.066 Y: 0.869 ± 0.057 Z: 0.890 ± 0.084
Total length of the COG trajectories	caregiver: 542 ± 31.8 (mm) client: 505 ± 34.2 (mm)	caregiver: 655 ± 53.9 (mm) client: 643 ± 52.8 (mm)
correlation coefficient between caregiver and client	X: 0.955 ± 0.021 Y: 0.916 ± 0.030 Z: 0.900 ± 0.065	X: 0.944 ± 0.040 Y: 0.901 ± 0.045 Z: 0.954 ± 0.021
Jerk-cost per second	$(5.05 \pm 1.21) \times 10^{11}$ [(mm/s³)²/s]	$(10.9 \pm 6.36) \times 10^{11}$ [(mm/s³)²/s]
Impulse	$(58.6 \pm 8.02) \times 10^{3}$ (N·s)	$(84.5 \cdot 13.0) \times 10^{3}$ (N·s)

between 155 and 162 cm tall and weighed between 44 and 60 kg. The students were taking a course in care methods and practiced care procedures several times a year with other students. The care-receiving subject was a male in his 20 s, who was 172 cm tall and weighed 69 kg. The care-receiving subject was requested to relax the muscles throughout his body during the experiment.

The analyzed motion was lifting a patient from the prone position on a bed into the sitting position. This motion is a basic and typical care giving motion and requires the caregiver to support the body weight of a care-receiver safely and comfortably during the movement. As shown in Fig. 1, the care-giving subjects were positioned on the right side of the care-receiving subject on the bed (Fig. 1(a)), and the caregiver performed the entire motion of raising (Fig. 1(b)) and seating the care-receiving subject on the side of the bed (Fig. 1(c)).

After two practice trials, the subjects performed the motion for measurement three times.

The apparatus used to measure body movement was a three-dimensional motion analysis system with six cameras (VICON512 motion capture system, Oxford Metrics Inc.). The frame rate was 120 Hz. Sixteen reflective markers were attached over specific body landmarks (Fig. 2). Markers were fixed on parts of the care-giving and care-receiving subjects' bodies. The starting point of the motion was determined using a ground reaction meter.

The body's center of gravity was approximated using a rigid link model, consisting of 11 segments: two each for the bilateral upper arms, forearms, femurs, cruses, foot regions and the head and trunk. Each segment was determined based on the above 16 marker points.

Based on the data of the marker position and the position of the center of gravity within each segment, the body's center of gravity in the care-giving and care-receiving subjects was determined by calculating the weighted mean of the centers of gravity in the segments. Although data for all marker positions were required to determine the body's center of gravity, when a marker was behind the body (in relation to the apparatus), the body's center of gravity was determined by spline interpolation using the positions of the near markers.

The time when the ground reaction of the care-giving subject changed was defined as the starting point, and the time when the movement of the body's center of gravity in the care-receiver was stopped was defined as the completion point. The trajectory of the body's center of gravity in the care-giving and care-receiving subjects was analyzed as follows:

(1) Correlation of the trajectory of the body's center of gravity in a single caregiver between the three trials.

(2) Correlation between the trajectories of the body's center of gravity in the care-giving and care-receiving subjects.

(3) Total length of the trajectory of the body's center of gravity (m).

$$\sum_{i=1}^{n}\sqrt{(x_{i+1}-x_i)^2+(y_{i+1}-y_i)^2+(z_{i+1}-z_i)^2} \qquad [2]$$

Here, xi, yi, and zi denote the x, y, and z coordinates, respectively, at a point in time i, and n denotes the total number of data.

The correlation coefficient was determined on each coordinate axis by pair comparison of the trajectory in the care-giving subject's body's center of gravity during each trial for (1), and by comparison of the care-giving and care-receiving subjects for (2). The movement velocity and acceleration of the body's center of gravity were determined on three-dimensional coordinates, and characteristics of each trial were examined. The movement velocity of the body's center of gravity was calculated by differentiating its position vector, and the acceleration of the body's center of gravity was determined by differentiating the movement velocity. The jerk (J) of the body's center of gravity was determined, Jerk-cost (JC) was calculated as the time integral of J, and the JC per unit time was determined by dividing JC by each operation time. Velocity, acceleration, and jerk data were smoothed using a fourth order, zero lag Butterworth filter after taking the first, second, and third derivations of the position data, respectively. To determine the kinetic momentum, impulse (I) was calculated by multiplying the value obtained by the time integral of the acceleration curve of the care-receiver from starting time to completion time during each trial by the body weight of the care-receiver. It was assumed that the care-receiver was relaxed.

$$JC=\int_{0}^{T}\left|a\right| \times m dt \qquad [3]$$

Here, a denotes acceleration, and m denotes the body weight of the care-receiver.

RESULTS

The operation time required for body movement was about 3 sec for the skilled caregivers and about 5 sec for the unskilled caregivers (Table 1). The difference in mean operation time between the two groups using the Welch t test was significant ($p<0.05$).

Figure 3 shows typical trajectories of the body's COG of skilled and unskilled caregivers in the X-Y (horizontal) plane. Good reproducibility was observed among the skilled caregivers (Fig. 3(a)) but was barely observed among the unskilled caregivers (Fig. 3(b)). The correlation of the movements among the three trials showed the same results (Table 1). The mean total lengths of the trajectory of the body's COG of the caregivers and care-receiver were significantly shorter for the skilled caregivers than for the unskilled caregivers ($p<0.05$) (Table 1).

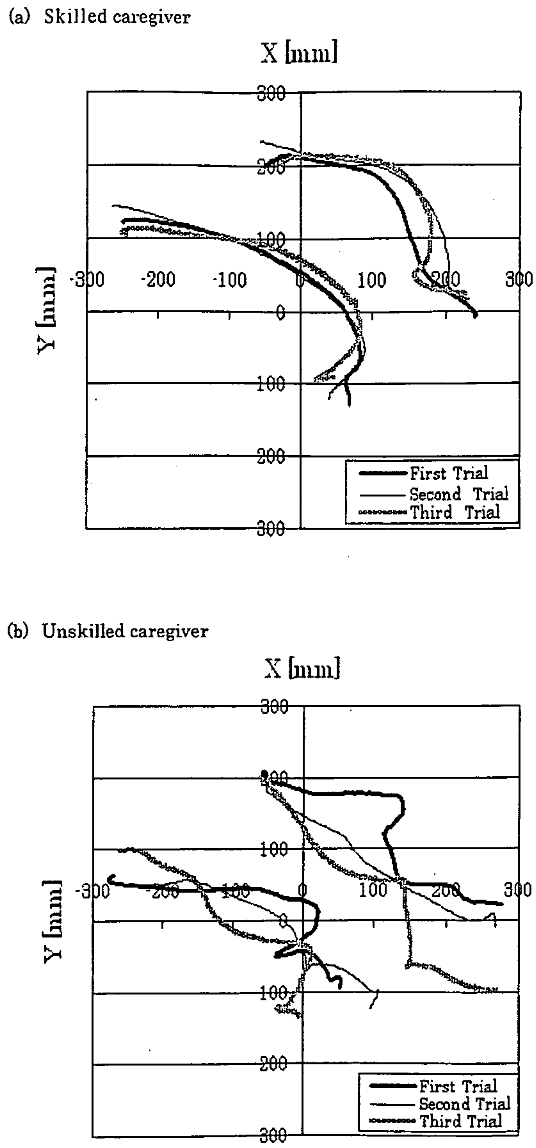

Fig. 3. Trajectories of body's center of gravity in caregivers and care-receivers in the X-Y plane.

Figures 4(a)–(c) show the trajectories of the body's COG of the three skilled caregivers and the care-receiver during the first trial, and Figs. 5(a)–(d)

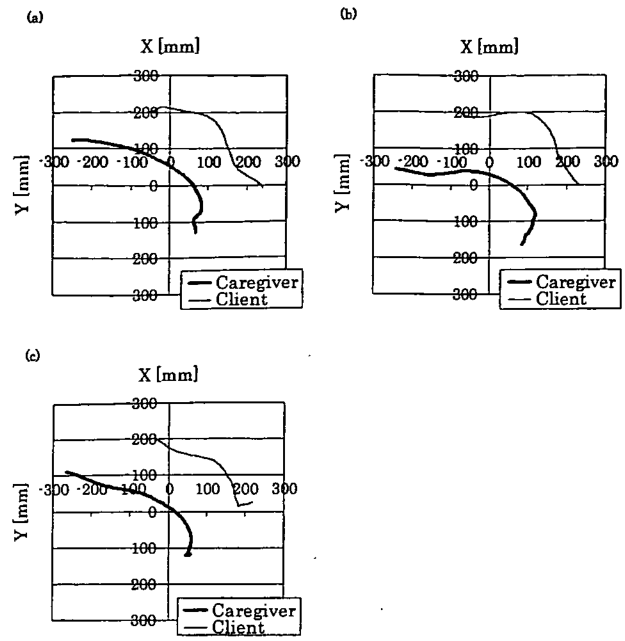

Fig. 4. Trajectories of body's center of gravity in skilled caregivers and care-receivers in the X-Y plane.

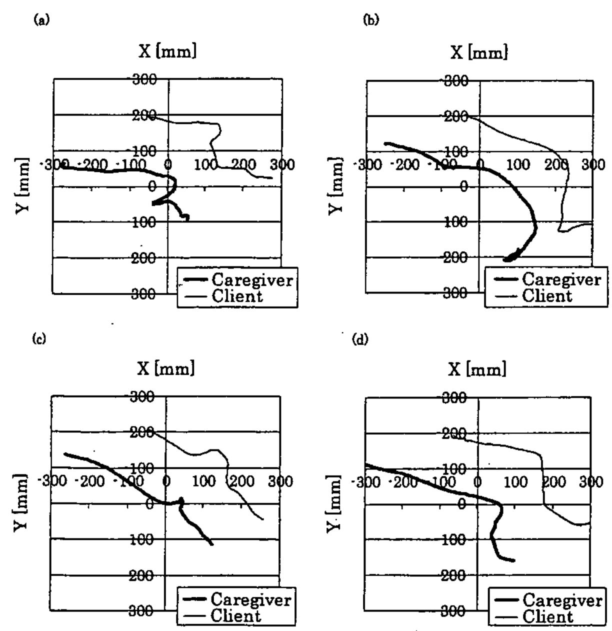

Fig. 5. Trajectories of body's center of gravity in unskilled caregivers and care-receivers in the X-Y plane.

show those of the four unskilled caregivers and the care-receiver during the first trial. The trajectories of the three skilled caregivers showed smooth curves, while the trajectory shapes of the unskilled caregivers were markedly varied. The correlation

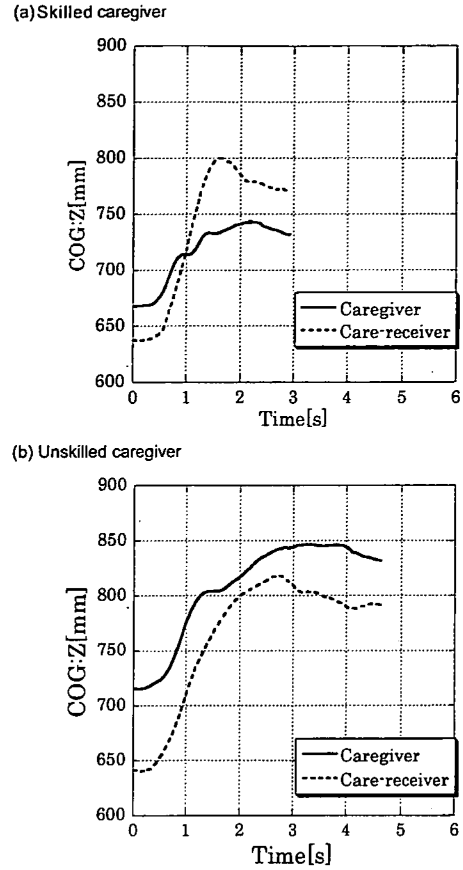

Fig. 6. Trajectories of body's center of gravity in the caregivers and the care-receivers in the direction of the vertical axis.

coefficients of the trajectories of the body's COG between the caregiver and care-receiver were high among all pairs (Table 1).

Figure 6 shows typical trajectories of the body's COG in the Z-axis direction (vertical direction). As shown in Fig. 6(a), the perpendicular movement of the body's COG of the skilled caregivers was 76–97 mm, and the position of the body's COG of the caregivers was lower than that of the care-receiver after a certain care-giving point in time. Perpendicular movement was also greater (132–220 mm) for the unskilled caregivers (Fig. 6(b)) than for the skilled, and the unskilled caregivers' bodies' COGs were always higher than that of the care-receiver.

In the motions of skilled caregivers (Fig. 7(a)), the velocity of the motion increased rapidly and then decreased rapidly. The mean of the highest velocity of the three skilled caregivers was 0.40–0.48 m/sec. For the unskilled caregivers (Fig. 7(b)), the mean

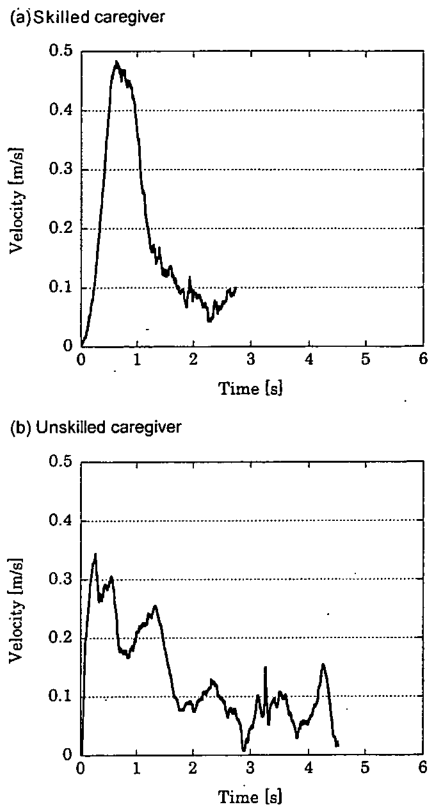

Fig. 7. Velocity of body's center of gravity in caregivers.

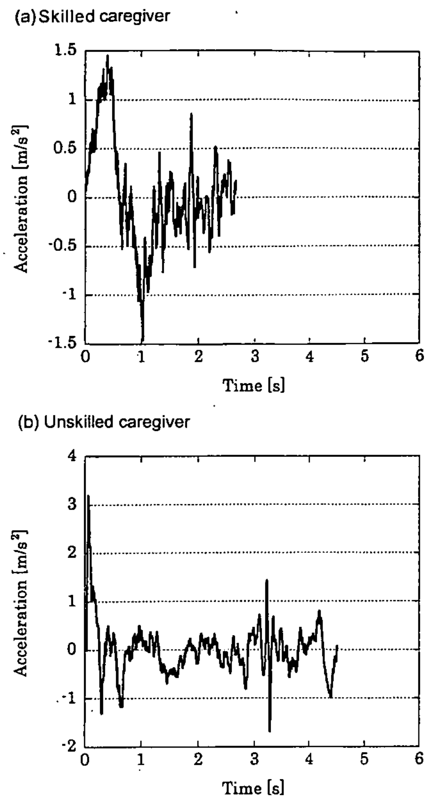

Fig. 8. Acceleration of body's center of gravity in caregivers.

highest velocity was lower (0.22–0.32 m/sec).

Figure 8 shows the acceleration of the body's COG in the caregivers. For the skilled caregivers (Fig. 8(a)), acceleration increased soon after the start of motion and showed a single peak. For the unskilled caregivers (Fig. 8(b)), the highest acceleration was lower than that of the skilled, and acceleration and deceleration alternated irregularly.

The jerk-cost per unit time was lower for the skilled caregivers than for the unskilled caregivers (Table1), and the difference in the mean jerk-cost was significant ($p<0.05$).

Impulse in all trials was lower for the skilled caregivers than for the unskilled caregivers (Table 1), and the difference was significant ($p<0.05$).

DISCUSSION

In this study, we demonstrated that there are significant differences between the smoothness of trajectories of the body's COG of skilled and unskilled caregivers, and the JC of movement of skilled caregivers' was less than that of unskilled caregivers' (Table 1). The skilled caregivers' motions also showed a bell-shaped velocity curve.

Moreover, the movements of skilled caregivers were highly reproducible and stable. This result suggests that trajectories of skilled caregivers were produced from movements based on the same model. If we take these results into consideration, it is reasonable to suppose that JC is applicable as a parameter for the care giving motion.

We also analyzed the movements of the caregiver and the care-receiver in parallel. The trajectories of the caregivers' bodies' COGs were similar to those of the care-receiver's, and the correlation coefficients of the trajectories between the caregiver and care-receiver were high for both skilled and unskilled caregivers (Table 1). Therefore, the JC to the care-receiver when assisted by a skilled caregiver was less than when assisted by an unskilled caregiver. Since jerk is the rate of change in acceleration, the unskilled caregivers may frequently have accelerated and decelerated movement of the care-receiver's body. A smooth trajectory of the body's COG during the care-

Table 2. Characteristics of movement in skilled caregivers

1. Smooth trajectory of the body's COG
2. High velocity in the initial stage and single peak of acceleration
3. Effective use of elements of force, such as inertia
4. Minimization of energy required for care-giving motions by reducing impulse and total movement of the body's COG
5. Lower position of COG in the caregiver than in the care-receiver means reduction of stress on the lumbar and other vulnerable regions

receiving period is considered important to the comfort of the care-receiver, suggesting that this should be a parameter for appropriate care-giving motions.

Kjellberg[15] argued that the quality of work techniques used in the health care sector were positively correlated with the patients' perception of safety and comfort. Our study's results support his conclusion.

Other differences were found in the characteristic motions of skilled and unskilled caregivers. There were significant differences in operation time, total length of the trajectory of the body's COG, and impulse between skilled and unskilled caregivers (Table 1). The rapid completion of the care-giving motion by skilled caregivers was due to the high velocity of the initial motion, which also reduced impulse and kinetic momentum. Observation of the care-giving motions of the skilled caregivers suggested that the force of inertia was effectively used by quickly accelerating the motion of the care-receiver's body in the initial stage of movement.

The perpendicular movement of the skilled caregivers' bodies' COGs was smaller than that of the unskilled caregivers' bodies. The positions of the skilled caregivers' bodies' COGs were lower than that of the care-receiver's body's COG, but for the unskilled caregivers, they were generally higher than the care-receiver's. The skilled caregivers reduced movement of the body's COG against gravity, and suppressed anterior bending of the trunk of the body by positioning their bodies' COGs lower than that of the care-receiver's body, leading to a motion that did not increase lumbar stress.

Based on these findings, the characteristics of movement in skilled caregivers were as follows: smooth trajectory of the body's COG, high velocity in the initial stage and single peak of acceleration, effective use of elements of force such as inertia, minimization of energy by reducing impulse and total movement of the body's COG, and lower position of COG in the caregiver than in the care-receiver (Table 2).

In conventional caregiver training courses, trainees practice and repeat care-giving techniques until they become expert in the techniques. However, handling of patients causes a lot of physical stress in caregivers, often resulting in musculoskeletal disorders[16–19]. Inexpert care techniques have been reported as a cause of such disorders[20]. To help trainees acquire skills, it is important to not use repeated exercises as the only guide. Application of parameters of skill in care-giving motions is also important. The problem of how to apply these parameters in the training course should be examined in follow-up studies.

In this study, there were a limited number of subjects, and evaluation was limited to a single care-giving motion. We will re-examine the parameters used in this study by quantifiably evaluating various care-giving motions with a larger number of subjects and establishing criteria for learning care-giving motions and efficient methods of training in care-giving motions.

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