

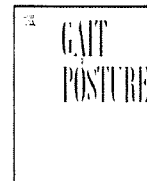
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Short communication

Olfactory stimuli and enhanced postural stability in older adults

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ABSTRACT

Ameliorating postural instability is an important component of geriatric health care. The effect of olfactory stimuli (lavender and black pepper oils) on postural control in 17 older adults (78 ± 6 years old) who had no apparent neurological deficits was studied. Measurements of center of pressure (CoP) trajectories were done with subjects standing quietly on a force plate. Control measurements were compared with olfactory interventions: brief exposure to sham (distilled water), lavender oil, and black pepper oil; experiments were repeated with eyes open and eyes closed. From the CoP data, the root mean square (RMS) displacement and velocity in mediolateral (ML) and antero-posterior (AP) directions, and the total trajectory length were computed. This study found that with eyes closed, olfactory stimulation with either lavender or black pepper oil significantly decreased both ML and AP RMS velocities and trajectory lengths compared with baseline. In contrast, little effect was observed under the eyes-open condition. Decreases in RMS displacements were small and mostly insignificant. The study suggests that olfactory stimulation may improve posture stability in older adults through decreasing the velocities of postural adjustments during normal sway.

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1. Introduction

Increased postural instability in older adults is well established [1,2], and increased postural sway has been associated with the incidence of falls in older adults [3,4]. Many factors contribute to loss in balance control, including diminished vision, muscle weakness, vestibular disorders, bone integrity, spinal injury, and somatosensory deficit [5].

It has traditionally been thought that balance control occurs at an autonomic level, involving a complex interplay between vision and noncortical polysynaptic brainstem pathways associated with the vestibular apparatus and proprioception [6,7]. However, recent research has suggested that the cerebral cortex may be involved in controlling specific aspects of balance [8]. Odor is one of the strongest stimuli over a wide range of the cerebral cortex [9]. Moreover, there are brain diseases, such as Alzheimer's, schizophrenia, and certain types of stroke, which manifest both olfactory dysfunction and balance instability [10–12], suggesting that both neuronal deficits may be linked. However, data are lacking regarding the relationship between olfactory stimulation and postural stability. In order to investigate this, we gave odor stimuli using

black pepper and lavender oils to subjects, and measured several indices of postural stability.

2. Methods

2.1. Subjects

We used posters to recruit community-dwelling older adult participants from communities surrounding Sendai, Japan. Seventeen subjects, age 78 ± 6 years, male/female ratio of 13/4, completed the study. The experimental protocol (2007–192) was approved by the institutional ethics committee, and verbal informed consent was obtained from each subject. Criteria for participation included being medically stable, adequately comprehending instructions and the nature of the study, and being able to stand up and walk independently without a cane or assistance device. Functional independence was assessed with the Barthel Index (subject range 80–95). Exclusion criteria included evidence of arthritis in the lower limbs, chronic back, knee or hip joint pain, evidence of Parkinson's disease, Meniere syndrome, cerebellar signs, cognitive deficits (Mini-Mental State Examination: MMSE < 24), or peripheral neuropathy under standard neuropsychological assessment.

2.2. Protocol

Black pepper and lavender oils (#T03218 and #060706) were purchased from Yamamoto Perfumery Co., Osaka, Japan. Trials were conducted between 10:00 a.m. and 11:00 a.m. on separate days (minimum 2-day separation) to minimize a placebo or learning effect, as well as to insure stimulus clearance and a return to olfactory baseline. The order of the two oil and one sham trial exposures were randomly selected for each subject.

Subjects were instructed to stand with their feet slightly apart on a force plate. For each stimulus, the protocol was: 1 min eyes-open control trial, 2 min break,

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1 min eyes-closed control trial, 4 min break, 1 min eyes-open stimulus trial, 2 min break, 1 min eyes-closed stimulus trial. For the stimuli, an investigator held a paper stick, previously dipped in one of the oils or in distilled water, within a few centimeters of, but not touching, the right side of the subject's nose. The stick was re-dipped prior to each trial or corresponding break and held continuously from the time of exposure to the end of the eyes-closed stimulus trial. During eyes-open trials, subjects were instructed to look straight ahead. During the breaks, which were given to avoid fatigue, subjects were instructed to sit and relax. These were not blind studies, as the odor of the oils (and its absence in the shams) was more than sufficient for detection by all subjects.

2.3. Measurements

Movement of the body center of pressure (CoP) was measured with a force plate (Gravicoda GS-2000, Anima, Tokyo). Signals from its three force transducers were sampled at 100 Hz, obtaining individual 4096 long data strings, over 41 s periods during each trial. The data were filtered and compressed with a 9-point Gaussian filter using central binomial coefficient weighting. For each set of data, comprising six combinations of independent variables (three interventions and two visual conditions), the mediolateral (ML) and antero-posterior (AP) components of the CoP were computed. We derived five indices from these data: the total trajectory length; the root mean square displacements (RMSdisp) of the CoP (ML and AP), and the RMS velocities (RMSvel) of the CoP (ML and AP).

Variations among the control measurements by interventions were assessed by ANOVA with the Tukey post hoc test. Tests of the null hypothesis of no change relative to baseline were assessed with a paired two-tailed Student's *t*-test. Significance was taken at $p = 0.05$.

3. Results

Table 1 shows the population means \pm S.D. of the raw dimensional quantities measured. ANOVA revealed no significant differences in the control measurements with the different interventions, so these data were pooled.

Among the 30 combinations of measurements, the most consistent results were in the eyes-closed group, where we found, for both lavender and the black pepper stimuli, significant fractional decreases in RMSvel (ML and AP), and in total trajectory length. Fig. 1 shows these results. With three exceptions, no other condition rose to statistical significance. These were: %change in RMSdisp (eyes-closed, AP, lavender); RMSdisp (eyes-open, AP, lavender); and RMSvel (eyes-open, AP, sham). However, as these follow no consistent pattern, we speculate that they may be secondary to the small sample size in this study, and are of little physiological significance. Surprisingly, and contrary to our initial expectations, we found no consistent pattern of significant decrease in the RMS displacement of the CoP.

4. Discussion

This is the first study to investigate the relationship between olfactory stimulation and postural stability in older adults. In the current study, both black pepper and lavender improved the balance parameters such as RMSvel and trajectory length, suggesting that the posture stabilizing effect of olfactory stimulation is not odor specific. This is in contrast to the observation that

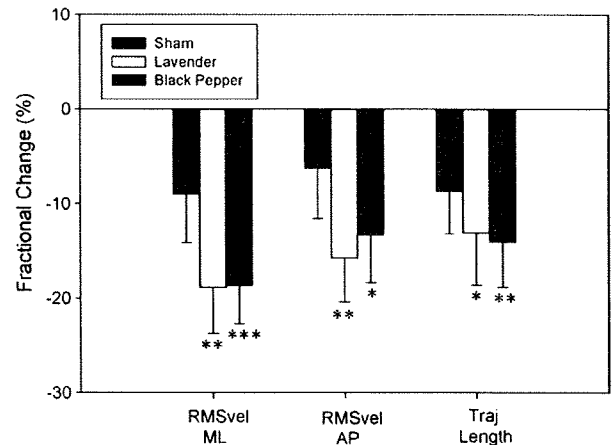


Fig. 1. Effects of odor stimulation on three posture stability indices under eyes-closed conditions. (With eyes open, neither olfactory stimulus showed any significant changes; data not shown.) Fractional changes are shown for RMS velocity in the mediolateral (ML) and antero-posterior (AP) directions, and for total trajectory length over the trial (Traj length). Data shown as means \pm S.E. Significance levels: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. The sham exposures did not reach statistical significance.

black pepper odor improved the swallowing reflex in dysphagic older adults whereas lavender oil did not [13].

It has previously been reported that poor balance with eyes closed is associated with an increased risk of falls [1,14], suggesting that the improvement of the balance with olfactory stimulation that we observed in similar conditions may be extrapolated to improving risk of falling in older people. This is in addition to the observation that aromatherapy with lavender has successful application in the treatment of behavioural and psychological symptoms of dementia [15].

The olfactory pathways project from the olfactory bulb widely throughout the cerebral cortex [16,17], although these studies were done in macaque monkeys. While there are important species differences, the fact that these are primates suggests an analogous projection may exist in humans. Moreover, it has recently been noted that the cerebral cortex is involved in upright posture maintenance in humans, especially in balance compensation mechanisms [5]. For instance, the insular cortex is importantly involved in the processing and integration of sensory information for balance [5], and is also activated by olfactory stimuli [13]. This suggests a mechanism by which odor stimulation may enhance cortical control of balance in older adults. This preliminary work thus suggests that odor stimulation may help ameliorate impairment of balance control in older adults, but further studies are necessary to apply these findings in practice.

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Conflict of interest statement

We declare that there are no financial or other conflicts of interest in relation to this work.

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Table 1

Pooled control values for postural stability indices based on center of pressure (CoP) measurements. RMSdisp and RMSvel: respectively root mean square displacement and velocity of CoP along the indicated axis. Traj length: total trajectory length of the CoP over the trial. ML: mediolateral, AP: antero-posterior. Data shown as means \pm S.D., $N = 17$.

Postural stability index	Directional axis	Visual condition: eyes-open	Visual condition: eyes-closed
RMSdisp (cm)	ML	0.51 \pm 0.17	0.73 \pm 0.25
	AP	0.53 \pm 0.19	0.71 \pm 0.21
RMSvel (cm/s)	ML	1.54 \pm 0.62	3.02 \pm 1.40
	AP	1.40 \pm 0.61	2.56 \pm 1.13
Traj length (cm)	N/A	85 \pm 38	156 \pm 69

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Caregiving burden for the oldest old: A population based study of centenarian caregivers in Northern Japan

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ABSTRACT

This study investigated caregiving burden of the oldest old specifically focusing on caregivers of centenarians and aimed to determine if caregivers of centenarians in Japan can be considered models for successful caregivers. Data was collected from 160 people aged 80–107 and 84 of their caregivers aged 24–92 using a self-reported questionnaire survey. Caregivers of centenarians do not exhibit significantly less burden, less prevalence of depression, or higher quality of life than caregivers of 80–99 year olds. Burdened caregivers experienced poorer general health (GH), more bodily pain (BP), less vitality (VT), difficulties with social functioning (SF), and poorer mental health (MH) than less burdened caregivers. While all caregivers scored below expected Japanese average scores for Health-related quality of life short form-36 (HRQoL SF-36), those reporting utilization of private care services, providing care regularly, and providing care for more than 5 h per day exhibited the lowest scores. Caregivers of centenarians may not represent models of successful caregivers. Caregivers showed equal distribution of light and heavy burden among recipient age groups therefore it may be inferred that as care recipient age increases it is not inevitable that they become heavier burdens on their caregivers. This is the first in-depth study to investigate the unique situation of centenarians and their caregivers in Northern Japan.

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1. Introduction

In the 20th century, the number of centenarians has greatly increased throughout the world. In Japan, the National Institute of Population and Social Security Research (2006) reported that the number of centenarians has risen dramatically from 153 in 1963 to over 25,500 in 2005. The number of centenarians is projected to rise to over 519,000 by the year 2050 in Japan and to over 3.2 million throughout the world (U.S. Census Bureau, 1999).

In Japan, over 86% of caregivers are informal caregivers (unpaid family caregivers) who live with the care recipients and of whom 85% are women and 53% are over the age of 50 (Ministry of Health, Labor, and Welfare, 2002). The care they provide reduces the demands on the health care system and can prevent or delay institutionalization or the need for more formal caregiving services (paid care provided by trained health care professionals).

In Japan, the traditional expectation that children provide informal care for their aging parents rooted in Confucius ideals of

filial piety continues in the modern era. Filial piety, an internalized part of cultural values in Japan, continues to be taught in moral education classes beginning in elementary school (Mizuno and Takashaki, 2005). Creighton-Campbell and Ikegami (2000), note that with fewer children, more women working, and changing attitudes towards family responsibilities, the traditional system of informal caregiving in Japan is widely viewed as being in crisis, or at least inadequate. In order to strengthen family functioning and reduce caregiver burden in households, the Japanese government introduced a system of Long-Term Care Insurance (LTCI) (called Kaigo Hoken in Japanese) in April 2000.

Following policies in the Netherlands and Germany, Japan was the third nation to provide LTCI in the world. Under the slogan "From Care by Family to Care by Society" and promising "socialization of care" for frail elderly, the Japanese government inaugurated the public LTCI system aiming to provide citizens with a system in which society as a whole supports the burdens associated with care (Tsutsui and Muramatsu, 2005) with the main goal to shift the majority of responsibility for caregiving from the family to the state.

Since the introduction of LTCI in April 2000 perspectives towards caregiving have begun to change in the younger generations. Arai (2006) reported that in less than 1 year after the introduction of LTCI system in Japan more caregivers began to believe that society must look after the elderly. As people have

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become more accepting of care services and usage of LTCI services has dramatically increased. During the first 6 years (April 2000–March 2006), the Ministry of Health, Labor, and Welfare (2006) reported the number of certified individuals who received a support or care needs level increased 109% to 4.56 million, which was far beyond the growth of populations aged 65 and older and 75 and older (20% and 34%, respectively). The Ministry further states that the number of LTCI home care users increased 180% to 2,724,100 and the number of LTCI institutional service users increased 56% to 813,200.

The only previous study focusing on caregivers of centenarians was conducted by Nishikawa et al. (2003) who found that although caregivers of centenarians exhibited worse ADL abilities than caregivers of controls they reported lower levels of fatigue, anxiety, depression, and irritability. These results were attributed to the genuine concern and caring by centenarian caregivers and Nishikawa et al. (2003) proposed that situations of centenarian care may serve as a possible model for successful care.

The present study sought to provide a thorough investigation of the caregiving burden associated with caring for the oldest old in Japan. By examining levels of caregiver burden, depression, and quality of life, this study aimed to determine if caregivers of centenarians in Japan can be considered models of successful caregivers. Due to changes in public thinking from the introduction of LTCI, this study may be one of the last opportunities to gain understanding into the life and perspectives of informal caregivers and the burdens they feel in providing community based care for their aging family members. It is also one of the first opportunities to examine how these traditional perspectives are changing under the new health care system and how caregivers are utilizing the new health care services.

2. Subjects and methods

2.1. Selection of patients and caregivers

Official city resident registrars located at seven municipal offices throughout Sendai City, the second largest city in Northern Japan with a population of approximately 1 million people, were manually searched by the principal investigator (S.F.). 135 registered centenarians (individuals aged 100 years or older as of 1 January 2007) were included for entry to the present study. Simultaneously, 135 people aged 90–99 and 135 people aged 80–89 who were listed in the registrar books immediately after each centenarian were also recorded as controls subjects. Questionnaires were sent to 405 residents on the same date.

The questionnaires were separated into two sections. Section A was comprised of questions relating to the demographics, care receiving situation, activities of daily living (ADL), and independent activities of daily living (IADL) of the respondent. This section was to be completed by either the respondent or their caregiver. Section B, comprised of questions relating to the situation of the caregiver including caregiver demographics, situation of care and support network, caregiver burden, caregiver depression, caregiver quality of life, communication between care recipient and caregiver, and caregiver opinions towards caregiving, was to be completed by the respondents' primary caregiver. If the individual did not have a caregiver they were requested not to complete section B.

2.2. Measures

Functional ability of respondents was assessed using the Barthel Index (BI) (Collin et al., 1988). More complex independent activities were evaluated using an IADL scale created by Lawton and Brody (1969).

To analyze the levels of care required this study used the LTCI care needs level designations given to recipients by the Japanese Ministry of Health, Labor, and Welfare. After LTCI eligibility has been determined individuals are divided into three classifications: uncertified (considered self-supporting and do not receive a needs level), support needs level 1 or 2 (require support with daily activities referred to as preventative services), and care needs levels 1–5 (require continuous care). Uncertified self-supporting individuals are eligible to receive services not covered by LTCI such as meals on wheels or light daily assistance such as shopping, gardening, housecleaning, etc. Individuals requiring long-term care and/or requiring daily assistance receive a care needs level and are divided between support needs levels 1 and 2 and care needs levels 1 through 5 depending on the level of disability. Individuals with support needs care levels (called *yoshien* in Japanese) are able to receive in-home services such as home helpers, day services, short-term stay services, rental of welfare equipment, etc. under a LTCI care plan. More disabled individuals, such as bedridden people or individuals suffering from dementia who require community or institutional long-term services, are divided among the care needs levels (called *yokaigo* in Japanese) ranging from 1, those needing some care, to 5, for those needing the highest levels of care. Care needs level individuals are eligible for in-home services as well as services at facilities which include special nursing homes for the elderly, care at facilities for elderly requiring long-term care, and hospitals with a large number of long-term care staff.

The Japanese version of the Zarit Burden Interview (J-ZBI) (Arai et al., 1997) and the Burden Index of Care (BIC) (Miyashita et al., 2006) were used to measure caregiver burden. The J-ZBI, a care burden scale originally developed by Zarit et al. (1980) and translated into Japanese consists of 22 items assessed by a 5-point Likert scale to provide a total score ranging from 0–88, with a higher score representing a greater care burden. It is a generic measure of burden associated with financial/behavioral impairments in the home care situation (Zarit et al., 1980). The BIC is a concise multidimensional care burden scale that reflects circumstances unique to Japan (Miyashita et al., 2006). It is similar to the J-ZBI but differs in that it was originally written in the Japanese language and therefore no issues with translation validation exist. The BIC measures 5 domains with 11 items and includes a "service related burden" (Miyashita et al., 2006). Using the total mean J-ZBI score of 36.39 in this study, caregivers were split into two groups less burdened ($n = 38$) and heavier burdened ($n = 39$).

To analyze the risk of depression among caregivers, the 5 item Geriatric Depression Scale (GDS-5) was used (Rinaldi et al., 2003); these latter authors found both the original 15 item Geriatric Depression Scale (GDS-15) (Sheik and Yesavage, 1986) and the GDS-5 are often not well received by elderly individuals therefore the GDS-5 was chosen to minimize feelings of discomfort and to shorten questionnaire length. A score of 2 or more on the GDS-5 indicates the presence of depressive symptoms.

The quality of life of caregivers was evaluated using the Japanese version 1.2 of the HRQoL SF-36 (Fukuhara et al., 1998). The HRQoL SF-36 is a widely used tool comprised of eight health subscales: physical functioning (PF) measuring the level of limitations in performing physical activities, role physical (RP) measuring the level of difficulty in performing work or other daily activities, BP measuring the level of and limitations from pain, GH measuring degree of personal health, VT measuring level of energy from tired and worn out to being full of pep and energy, SF measuring the ability to perform normal social activities with or without interference due to physical and emotional problems, role emotional (RE) measuring the ability to conduct daily activities in relation to emotional problems, and MH measuring feelings ranging from nervousness and frequent depression to feelings of peace, happiness and calmness (Ware and Gandek, 1998).

For analysis in this study care services were grouped into formal and informal services. Formal services include LTCI services which are subsidized by the government and provided to individuals who have received a LTCI support or care needs level certification and private services which are completely paid for by the recipient.

2.3. Statistical analysis

Statistical analysis was conducted using Microsoft Office Excel 2003 and SPSS v. 15.0. Analysis was performed using independent samples tests, two-tailed *t*-test for equality of means, Kruskal–Wallis one-way analysis of variance, and test of means using ANOVA. A value of $p < 0.05$ was considered significant.

3. Results

Of the 405 surveys, 160 (39.5%) completed questionnaires and 44 (10.8%) refused were returned to the author, 17 (4.2%) notifications of deaths were received, 4 (0.9%) surveys were returned as undeliverable mail, and 180 (44.4%) remained unanswered. Included in this study were 56, 48, and 56 respondents aged 80–89, 90–99, and 100–107 years old, respectively.

3.1. Centenarian results

Characteristics of centenarians and control respondents are shown in Table 1. Mean BI and IADL scores decreased with care recipient age ($p < 0.001$) and differed by sex ($p < 0.001$). BI mean scores for centenarian respondents were 20% lower than 90–99 year old and over 40% lower than 80–89 year old respondents. The mean IADL score for centenarian respondents was much lower than control respondents. While minimal gender difference in IADL mean score was observed between 80–89 year olds and centenarians, 90–99 year old males were more functionally independent than 90–99 year old females ($p < 0.01$).

3.1.1. Housing status

As seen in Table 1, institutionalization rates increased as the age of the respondent increased ($p < 0.001$) though the ratio of institutionalized to community dwelling centenarians is slightly less than that of 90–99 year old control subjects. Among total community dwelling elderly, 91.5% (119/130) lived in family and multigenerational households. Over 42% (55) reported living with their biological children while 31% (41) lived in multigenerational families. Second generational families, which include children and grandchildren, were more prevalent than 3rd generational families which include children, grandchildren, and great grandchildren. While some 80–89 and 90–99 year-old individuals lived with their spouse or alone (15.5% and 6.3%), only one centenarian lived independently and no centenarians had a living spouse. The majority of the centenarians (71.4%) continued to live in their own private home.

3.1.2. Status of care

The proportion of individuals receiving care regularly increased as respondent age increased ($p < 0.002$) (Table 1). Centenarians were 22% more likely to receive care regularly than controls. Although 89 out of 156 respondents reported receiving care regularly only 50% reported receiving LTCI services and 11% reported receiving private services. Forty percent more centenarians used insurance services than 80–89 year olds.

An application for LTCI had been made by 64.6% of the respondents (Table 2). Over 39% (63) of respondents currently do not have a LTCI support or care needs level and are considered self-supporting. Of these 63 respondents, 15 receive care regularly

Table 1

Background characteristics of the respondents by age, mean \pm S.D., *n* (%), range.

Age groups	80–89	90–99	100+
Characteristics			
Number of participants	56	48	56
Age (years)	83.7 \pm 2.2	92.4 \pm 2.2	102.0 \pm 1.3
Age, range	80–89	90–99	100–107
% females	50.0	70.8	82.1 ^{***}
Living arrangements, <i>n</i> (missing)			
Alone	7 (12.5)	3 (6.25)	1 (1.8)
With family	46 (82.1)	32 (66.7)	41 (73.2)
With spouse	16	7	0
With biological child	15	14	26
2nd generation	14	9	9
multigenerational housing			
3rd generation	1	2	6
multigenerational housing			
Institution	3 (5.3)	13 (27.1)	14 (25.0) ^{***}
Functional ability, <i>n</i> (missing)			
BI score			
Total	86.7 \pm 27.0	63.5 \pm 31.2	44.2 \pm 33.9 ^{***}
Male	77.1 \pm 30.9	91.8 \pm 15.2	48.5 \pm 39.4
Female	88.7 \pm 21.2	54.9 \pm 29.7	43.3 \pm 33.0
IADL score			
Male	3.5 \pm 1.7	4.0 \pm 1.2	1.3 \pm 1.6 ^{***}
Female	5.8 \pm 3.0	1.6 \pm 1.7	1.3 \pm 1.9 ^{***}
Status of care			
Receive care regularly, yes/no (missing)	18/35 (3)	30/17 (1)	41/15 ^{**}
Only receive formal care	5	7	9
Only receive informal care	3	6	3
Receive both	10	19	30
Receive neither of cares	38	16	14
Formal care			
Receive LTCI services, yes/no (missing)	15/38 (3)	24/23 (1)	39/16 ^{****} (1)
Receive private services, yes/no (missing)	5/49 (2)	4/43 (1)	8/46 (2)
Number of formal services received	0.7 \pm 1.6	2.1 \pm 3.0	2.5 \pm 3.3 ^{**}
Informal care			
Number of informal services received	0.7 \pm 1.6	2.1 \pm 3.0	2.5 \pm 3.3 ^{****}

Significance between the three age groups:

^{*} $p < 0.05$.

^{**} $p < 0.01$.

^{***} $p < 0.001$.

^{****} $p < 0.0001$.

Table 2

Status of LTCI.

	Controls	Centenarians
Number	104	56
% female	61.5	82.1
Formal care, yes/no (missing value)		
Applied for LTCI	60/42 (2)	42/14 ^{**}
Eligible for LTCI services	57/47	40/16 ^{****}
Receive insurance services	39/61 (4)	39/16 ^{****} (1)
Receive private services	9/92 (3)	8/46 (2)
Number of formal services received	1.4 \pm 2.5	2.5 \pm 3.3 ^{**}
Status of LTCI, <i>n</i> (%)		
Support care needs levels 1–2	19 (18.3)	0 (0)
Care needs levels 1–5	38 (36.5)	40 (71.4)
Do not have LTCI certification	47 (45.2)	16 (28.6)

Significance between three age groups:

^{*} $p < 0.05$.

^{**} $p < 0.01$.

^{***} $p < 0.001$.

^{****} $p < 0.0001$.

however these individuals are ineligible to receive care from LTCI such as subsidized homecare or day services.

The certification of LTCI care needs levels increase in relation to respondent age (Table 2). More than 71% of centenarians qualified for LTCI and received a care needs level compared to less than 38% of 80–89 year olds ($p < 0.001$). Sixteen (28.6%) centenarians did not have a LTCI support or care needs level and therefore were ineligible to receive support from LTCI services. The number of control respondents who had a certified support care needs level increase with age ($p < 0.005$). All centenarians who qualified for government LTCI received care needs levels. Over 70% of centenarian LTCI recipients were designated care level 3 or above and required heavier amounts of care. Centenarians were five times more likely to receive higher care level numbers than 80–89-year-old recipients and three times more likely than 90–99-year-old recipients.

Over 76% of respondents who received a support or care needs level reported receiving care regularly. The numbers of care needs level beneficiaries receiving care regularly significantly increased with respondent age from 52% of 80–89 year olds to over 90% of centenarians ($p < 0.001$). Over 75% of care needs level beneficiaries reported using insurance services while only 17.5% reported using private services. Receiving care insurance services significantly correlated with age as more than 87% of centenarians with care needs levels receive insurance services compared to 71.4% of 80–89 and 66.6% of 90–99-year-old controls ($p < 0.004$). Twenty percent of centenarians reported receiving private services.

3.2. Caregiver results

A total of 84 caregivers responded ranging in age from 24 to 92 (mean 64.32; males:females, 10:74). The distribution of caregivers based on recipient age groups of 80–89, 90–99, and centenarians were 18.5%, 35.8%, and 45.7%, respectively (Table 3). The great majority, 90.5% of caregivers were family members while 9.5% were

professional caregiving staff working in care institutions. The caregivers consisted of 44 (54.4%) biological children, 21 (25%) daughters-in-law, 7 (8.3%) spouses, 3 (3.6%) grandchildren, 1 (1.2%) sibling, and 8 (9.5%) paid caregiving staff. All 10 male caregivers were biological children of care recipients. Average caregiver age increased with the age of the care respondent group ($p < 0.001$). Over 77% of caregivers cared for the recipient in the community, 66.7% in their own home, 11.1% in their child's home, 17.3% in long-term care facilities, and 3.7% were cared for in hospital.

Seventy percent of caregivers cared for only the care recipient in this study. More than 58% (94) of caregivers responded that they received no assistance from other family members in the care of the recipient while 28.1% (45), 8.8% (14), and 4.4% (7) received assistance from one, two, or three family members, respectively.

Over 20% of family caregivers were employed at the time of this study. The mean age of employed caregivers was 5 years higher than unemployed caregivers (67.58 years vs. 62.81 years). The majority of working caregivers were full-time company employees (22.7%), self-employed (22.7%), part-time workers (22.7%), or employed in agriculture (18.2%). Other occupations included government employees, writers, volunteers, and child care workers. More than 40% of employed caregivers reported the need to change their job status after they began to care for the recipient. Changes included decreased work hours, leaving work early to accommodate caregiving, and quitting. Caregivers in all age groups reported receiving help from a similar number of people, however caregivers of centenarians reported receiving significantly more support from other family members ($p > 0.04$). Caregivers of younger recipients were most likely to be members of caregiver support groups ($p > 0.04$).

Care recipients reported receiving 16 different formal services and 17 informal services (Fig. 1A and B). Formal services were primarily focused on IADLs (47.6%) followed by ADLs (32%) and medical (20.4%). Informal services focused mainly on ADLs (50.5%) followed by IADLs (45%) and medical (4.5%).

Table 3
Caregiver characteristics by respondent age groups, n, mean \pm S.D., n (%).

Age groups	80–89	90–99	100+
No. of caregivers	15	29	40
Gender: men/women	1/14	4/25	5/32 (3)
Age (years)	62.6 \pm 14.9	61.7 \pm 14.2	67.0 \pm 11.2***
% of all caregivers	18.5	35.8	45.7**
Family caregiver age	65.5 \pm 10.7	66.6 \pm 9.1	67.0 \pm 11.2***
Professional caregiver age	25	40.2 \pm 16.1	na
Mean GDS-5 Score	1.1 \pm 1.0	1.7 \pm 1.3	1.4 \pm 1.1
% possible prevalence of depression	35.7	51.7	37.5
J-ZBI mean score	42.1 \pm 23.1	38.4 \pm 23.3	37.3 \pm 20.4
BIC mean score	38.1 \pm 25.6	30.3 \pm 23.2	30.0 \pm 21.7
Hours of caregiving per day	7.3 \pm 6.8	6.4 \pm 5.2	11.3 \pm 8.7
Hours caregivers can be relieved per day	2.9 \pm 2.0	3.4 \pm 2.5	7.1 \pm 9.9
Duration of caregiving in months	48.8 \pm 54.9	101.8 \pm 62.3	91.1 \pm 67.9
Number of family support people	0.3 \pm 0.7	0.67 \pm 1.0	0.8 \pm 0.8**
Employment status of family caregivers, employed/unemployed (missing value)	5/8 (1)	8/15 (1)	10/24 (1)
Does the caregiver have someone to talk to? Yes/no (missing value)	13/1 (1)	15/10 (4)	22/11 (7)
Is the caregiver satisfied with communication with the care recipient? Yes/no (missing value)	8/6 (1)	17/9 (3)	20/14 (6)
Does the caregiver belong to a support group? Yes/no (missing value)	4/11 (1)	5/22 (2)	1/34 (5)
Relationship to caregiver number	15	29	40
Family caregiver	14 (93.3)	24 (82.8)	38 (95.0)**
Grandchild	0 (0)	0 (0)	3 (7.5)
Daughter in law	2 (13.3)	6 (20.7)	13 (32.5)
Child caregiver	6 (40)	16 (55.2)	22 (55)
Spousal caregiver	6 (40)	1 (3.5)	0 (0)
Sibling	0 (0)	1 (3.5)	0 (0)
Homecare/LTC worker	1 (6.7)	5 (17.2)	2 (5)

na = not applicable; significance between the three age groups:

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

**** $p < 0.0001$.

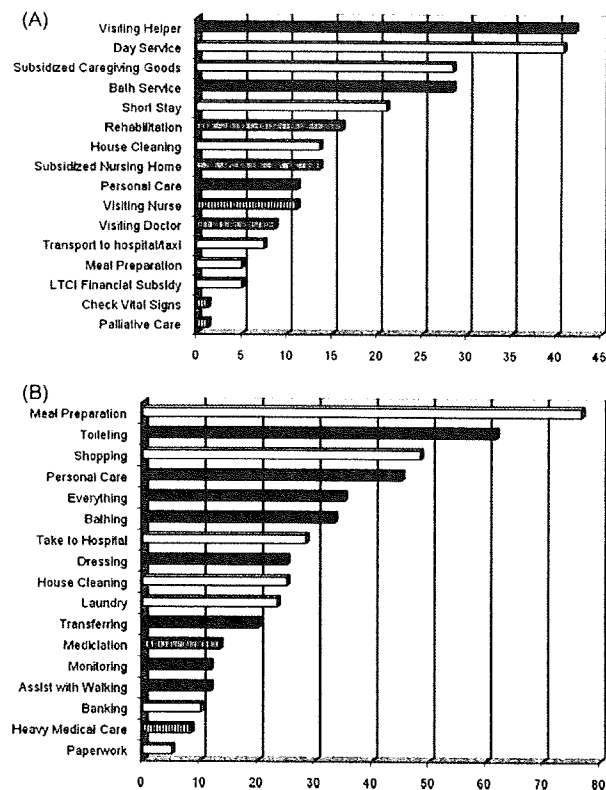


Fig. 1. Percentage of respondents reporting utilization of various formal and informal care services. For Figure A and B, ADL services are denoted in closed bars, IADL services are denoted in open bars, and medical services are denoted in striped bars. Part A shows formal services including services subsidized by LTCI and privately paid services. Part B shows the informal unpaid services caregivers report providing.

Over 44% of caregivers scored 2 or higher on the GDS-5 showing the presence of possible depressive symptoms. Caregivers showing possible signs of depression were more likely to have changed their job ($p < 0.05$) and less likely to receive assistance from private services ($p > 0.028$). Furthermore, receiving assistance from formal care services reduced the prevalence of depression from 56% for caregivers receiving 2 or fewer services to 30% for those receiving 3 or more formal services ($p < 0.015$). Female caregivers were more likely to show depressive symptoms in comparison to male caregivers (47% vs. 22%).

3.3. Caregiver burden results

Characteristics significantly related to high and low levels of caregiver burden are provided in Table 4. Caregivers of male care recipients were more likely to experience less burden ($p < 0.0001$) while male caregivers were more likely to experience heavier

Table 4
Caregiver burden, mean \pm S.D., n (missing values).

	80–89	90–99	100+	Total
Less-burdened caregivers (J-ZBI score: 0–36.39)				
Recipients				
Age	83.3 \pm 2.1	92.4 \pm 1.9	101.7 \pm 1.2	95.1 \pm 7.3
Gender (M/F)	5/2	2/11	5/13	12/26
BI score	56.7 \pm 35.6	61.5 \pm 34.2	42.0 \pm 36.7	51.3 \pm 35.9
IADL				
Female	2.5 \pm 3.5	1.9 \pm 2.2	1.5 \pm 2.3	1.7 \pm 2.2
Male	1.2 \pm 1.2	1.9 \pm 1.7	0.8 \pm 1.1	1.3 \pm 1.4

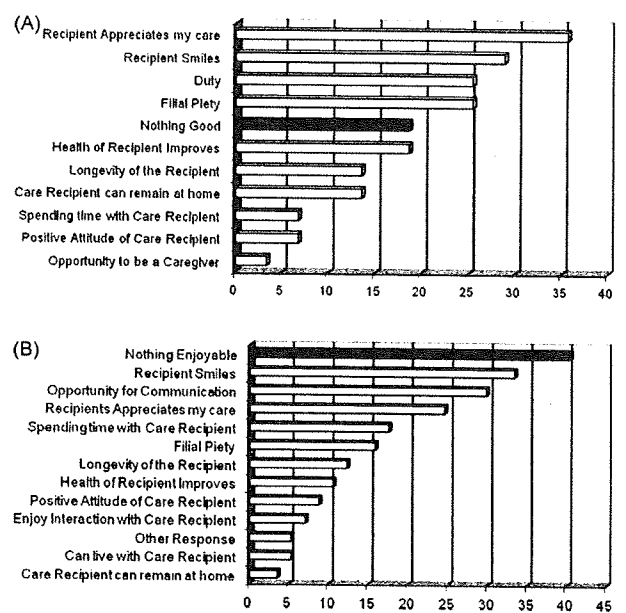


Fig. 2. Percentage of caregivers' perceptions towards caregiving. Part A reports caregiver responses to the question "What is good about caregiving?" Part B reports caregiver responses to the question "What is enjoyable about caregiving?" Closed bars denote negative responses while open bars denote positive responses.

burden ($p < 0.01$). Heavier burdened caregivers cared for recipients with lower BI ($p < 0.0005$) and lower IADL ($p < 0.001$). Caregiver burden significantly correlated with care insurance numbers given to care recipients ($p < 0.05$) (Table 5).

Caregivers listed a variety of answers when asked what they found good (Fig. 2A) and enjoyable (Fig. 2B) about caregiving. The 18% of caregivers who found nothing fun and 40% who found nothing enjoyable about caregiving experienced higher levels of caregiver burden than those caregivers who found fulfillment and satisfaction from caregiving ($p < 0.05$).

Burden was not significantly related to annual household income, caregiver relationship to the care recipient, or caregiver perceptions of satisfaction with communication with the care recipient. Although not statistically significant, the mean family income for employed family caregivers was lower than the mean family income for unemployed family caregivers while employed caregivers experienced less burden than unemployed caregivers. Caregivers employed in agriculture, self-employed, and employed in part-time jobs expressed the lowest burden among employed caregivers.

3.4. HRQoL results

All HRQoL SF-36 scores for caregivers are significantly lower than for the general Japanese population (Fukuhara and Suzukamo, 2004) even when controlling for age and gender (Fig. 3A)

Table 4 (Continued)

	80–89	90–99	100+	Total
Caregivers				
Age	65.8 ± 13.0	59.8 ± 10.9	68.3 ± 8.6	64.9 ± 10.7
Gender (M/F)	0/7	1/12	2/16	3/35
Caregiving hours/day	2.8 ± 2.2	9.7 ± 7.4	16.0 ± 8.5	9.9 ± 8.3
Relieved hours/day	3.3 ± 2.1	3.2 ± 2.1	3.6 ± 4.0	2.4 ± 1.5
Duration of caregiving/months	37.0 ± 40.1	97.8 ± 64.6	81.1 ± 47.3	79.2 ± 56.0
No. of services received	2.7 ± 2.7	3.2 ± 2.7	4.6 ± 3.9	2.0 ± 1.7
Number of helpers	1.4 ± 1.0	0.9 ± 1.0	1.1 ± 0.6	1.1 ± 0.9
Employment status (employed/unemployed)	4/3	2/8 (3)	7/9 (2)	13/20 (5)
Does the caregiver have someone to talk to? (yes/no)	6/0 (1)	7/4 (2)	9/8 (1)	22/12 (4)
Is the caregiver satisfied with communication with the care recipient? (yes/no)	5/2	6/5 (2)	12/5 (1)	23/12 (3)
Does the caregiver belong to a support group? (yes/no)	3/4	1/10 (2)	0/18	4/32 (2)
Housing status (private/institution)	6/1	11/2 (1)	15/3	32/6
Applied for support? (yes/no)	4/2 (1)	12/1	15/3	31/6 (1)
Receive care regularly? (yes/no)	5/1 (1)	10/3	15/3	30/7 (1)
Receive insurance services? (yes/no)	3/3 (1)	10/3	15/3	28/9 (1)
Receive welfare services? (yes/no)	0/6 (1)	2/11	3/14 (1)	5/31 (2)
J-ZBI	23.4 ± 8.5	18.6 ± 9.8	20.8 ± 8.9	20.5 ± 9.1
BIC	19.6 ± 13.2	11.8 ± 8.8	17.2 ± 13.3	15.7 ± 11.9
GDS (<2/>2)	4/3	7/6	8/9 (1)	19/18 (1)
HRQoL domain				
PF	60.8 ± 33.8 (1)	81.4 ± 14.3	75.5 ± 20.9	75.2 ± 22.0 (1)
RP	46.4 ± 39.3	36.5 ± 40.3	57.4 ± 41.2	48.0 ± 40.6
BP	64.9 ± 17.5	67.6 ± 20.9	64.3 ± 24.3	65.6 ± 21.5
GH	63.6 ± 13.5	63.1 ± 18.2	57.4 ± 20.6	60.5 ± 18.4
VT	69.8 ± 16.1	64.6 ± 28.0	57.4 ± 26.1	62.3 ± 25.1
SF	78.6 ± 15.7	70.2 ± 25.3	72.8 ± 28.7	73.0 ± 25.1
RE	61.9 ± 48.8	59.0 ± 45.5	64.7 ± 44.8	62.2 ± 44.6
MH	75.4 ± 14.3	70.5 ± 22.7	69.6 ± 21.9	71.0 ± 20.6
More burdened caregivers (J-ZBI score: 36.4+)				
Recipients				
Age	85.6 ± 2.4	92.2 ± 2.9	102.2 ± 1.5	95.6 ± 7.0
Gender (M/F)	2/5	0/14	1/17	3/36 ^{**}
BI score	54.8 ± 26.5	43.6 ± 19.0	35.4 ± 26.1	41.8 ± 24.3 ^{***}
IADL				
Female	0.8 ± 0.5	1.3 ± 1.5	0.9 ± 1.3	1.0 ± 1.3 [*]
male	0.9 ± 0.7	0.9 ± 0.9	0.7 ± 0.9	0.8 ± 0.9 [*]
Caregivers				
Age	58.0 ± 16.7	59.5 ± 15.5	66.3 ± 13.3	62.5 ± 14.8
Gender (M/F)	1/6	3/10	3/15	7/31 ^{**}
Caregiving hours/day	3.3 ± 1.5	4.3 ± 2.9	10.6 ± 9.2	7.1 ± 7.3 [*]
Relieved hours/day	3.3 ± 1.5	3.8 ± 3.1	7.6 ± 13.2	2.3 ± 1.5
Duration of caregiving/months	60.5 ± 68.5	90.1 ± 52.9	95.8 ± 82.8	87.8 ± 70.6
No. of services received	3.0 ± 1.7	4.0 ± 3.7	3.3 ± 2.8	2.5 ± 1.6
Number of helpers	1.0 ± 0.6	1.1 ± 1.0	1.3 ± 0.7	1.2 ± 0.8
Employment status (employed/unemployed)	1/4 (2)	5/6 (3)	3/14 (1)	9/24 (6)
Does the caregiver have someone to talk to? (yes/no)	6/1	6/6 (2)	13/3 (2)	10/25 (4)
Is the caregiver satisfied with communication with the care recipient? (yes/no)	2/4 (1)	9/3 (1)	8/9 (1)	19/16 (4)
Does the caregiver belong to a support group? (yes/no)	1/6	4/9	1/16 (1)	6/31 (2)
Housing status (private/institution)	6/1	7/7	14/1 (3)	27/12 (3)
Applied for support? (yes/no)	6/1	12/2	17/1	35/4
Receive care regularly? (yes/no)	7/0	13/1	17/1	37/2 ^{**}
Receive insurance services? (yes/no)	7/0	10/3	16/2	33/5
Receive welfare services? (yes/no)	4/3	1/12 (1)	2/15 (1)	7/30 (2)
J-ZBI	60.7 ± 16.4	56.8 ± 15.5	53.8 ± 14.1	56.1 ± 12.9 ^{****}
BIC	56.5 ± 21.3	47.7 ± 19.3	41.3 ± 21.7	46.3 ± 21.0 ^{***}
GDS (<2/>2)	5/2	5/9	12/6	22/17
HRQoL domain				
PF	83.9 ± 7.2 (2)	71.2 ± 25.3	76.2 ± 19.0	75.4 ± 20.6 (2)
RP	37.5 ± 43.3 (3)	41.1 ± 40.0	26.4 ± 32.6	33.3 ± 36.4 (3)
BP	35.6 ± 13.9	45.2 ± 21.5 (1)	43.5 ± 15.9 (1)	42.6 ± 17.7 ^{****} (2)
GH	41.3 ± 15.7	46.2 ± 10.6	44.5 ± 23.0 (2)	44.5 ± 17.5 ^{***}
VT	37.1 ± 17.3	45.7 ± 19.7	44.1 ± 18.2	43.4 ± 18.4 ^{***}
SF	37.5 ± 17.7	51.0 ± 18.0 (1)	47.1 ± 15.0 (1)	46.6 ± 16.8 ^{***} (2)
RE	25.0 ± 31.9 (3)	66.7 ± 39.2	38.9 ± 41.6	48.1 ± 41.7 (3)
MH	47.4 ± 14.1	55.1 ± 18.2	48.4 ± 15.0	50.7 ± 16.0 ^{****}

Significance for less-burden vs. more-burden total scores:

* $p < 0.05$.** $p < 0.01$.*** $p < 0.001$.**** $p < 0.0001$.

Table 5
The average J-ZBI caregiver burden score by recipient age group, mean \pm S.D.

Age groups	80–89	90–99	100+	Total
Care recipients				
Male	32.8 \pm 22.6	19.1 \pm 3.8	25.5 \pm 11.3	28.1 \pm 17.0 ^{***}
Female	51.3 \pm 21.1	39.9 \pm 23.5	39.7 \pm 21.1	41.1 \pm 22.1 ^{***}
Caregivers				
Male	44.32	40.8 \pm 18.7	52.4 \pm 23.1	47.0 \pm 19.7
Female	41.9 \pm 24.0	36.4 \pm 23.7	34.9 \pm 19.3	36.7 \pm 21.6
Status of LTCI				
Do not have a LTCI care needs level	29.3 \pm 3.2	26.3 \pm 9.9	26.9 \pm 22.9	27.5 \pm 16.6 [*]
Support care needs levels 1–2	47.7 \pm 35.4	28.0 \pm 25.1	na	32.9 \pm 26.7 [*]
Care needs levels 1–5	45.1 \pm 25.0	42.9 \pm 23.0	39.4 \pm 19.6	41.4 \pm 21.4 [*]
Caregiver data				
GDS-5 Score 0–1	48.5 \pm 26.1	33.3 \pm 21.0	41.7 \pm 17.2	40.7 \pm 20.7
GDS-5 Score 2–5	30.5 \pm 10.3	42.4 \pm 24.9	32.5 \pm 23.9	36.4 \pm 23.1
Receive care regularly	44.1 \pm 24.4	39.3 \pm 23.9	39.4 \pm 20.2	40.2 \pm 22.0
Do not receive care regularly	27.3	32.8 \pm 21.7	20.7 \pm 15.0	26.8 \pm 17.3
Employed caregiver	23.9 \pm 13.5	50.4 \pm 20.2	30.1 \pm 15.7	35.1 \pm 19.4
Unemployed caregiver	51.5 \pm 22.1	33.9 \pm 23.7	42.1 \pm 21.5	40.7 \pm 22.7
Have someone to talk to	40.3 \pm 22.2	39.1 \pm 24.9	40.0 \pm 20.4	39.8 \pm 21.7
No one to talk to	77.3	38.6 \pm 22.4	31.7 \pm 22.5	36.9 \pm 23.4
Satisfied with communication with care recipient	36.9 \pm 27.2	43.9 \pm 20.8	32.4 \pm 18.4	37.2 \pm 21.0
Not satisfied with communication with care recipient	47.7 \pm 20.4	29.4 \pm 26.2	45.0 \pm 22.7	41.1 \pm 23.7
Belong to a support group	35.5 \pm 27.1	54.1 \pm 16.3	61.4	47.4 \pm 21.7
Do not belong to a support group	44.7 \pm 22.3	34.7 \pm 22.9	36.5 \pm 20.6	37.3 \pm 21.5
Caregiver to care-recipient relationship				
Family caregiver	42.5 \pm 23.9	37.6 \pm 23.7	37.6 \pm 20.7	38.5 \pm 22.0
Spousal caregiver	35.5 \pm 23.8	na	na	35.5 \pm 23.8
Child caregiver	41.8 \pm 26.0	40.3 \pm 20.6	32.6 \pm 20.8	36.6 \pm 21.3
Daughter in law	61.9 \pm 15.3	34.1 \pm 32.5	45.1 \pm 17.2	43.4 \pm 21.3
Grandchild	na	na	44.7 \pm 28.2	44.7 \pm 28.2
Sibling	na	19.2	na	19.2
Homecare/LTC worker	36.4	33.8 \pm 19.0	28.4	33.3 \pm 15.0

na: not applicable as there are no respondents in the corresponding category.

^{*} $p < 0.05$.

^{**} $p < 0.01$.

^{***} $p < 0.001$.

^{****} $p < 0.0001$.

Table 6
HRQoL SF-36 results.

Parameters	PF	RP	BP	GH
Caregiver details				
Caregiver age				
<65	81.4 \pm 17.8 [*]	41.2 \pm 39.8	55.5 \pm 19.7	59.7 \pm 7.5 ^{***}
>65	72.0 \pm 19.5	42.1 \pm 38.7	50.9 \pm 25.6	48.1 \pm 20.2
Caregiver gender				
Male	89.8 \pm 10.1 ^{***}	50.0 \pm 42.5	65.1 \pm 26.2	53.1 \pm 19.7
Female	73.3 \pm 20.8	39.7 \pm 38.5	52.0 \pm 21.8	52.2 \pm 19.8
Status of care				
Receive care regularly				
Yes	75.3 \pm 19.7	41.0 \pm 38.9	52.9 \pm 21.2	52.0 \pm 20.5
No	78.2 \pm 20.8	42.5 \pm 37.4	68.9 \pm 32.2	60.3 \pm 13.2
Receive private services				
Yes	67.0 \pm 19.7	27.5 \pm 39.9	44.1 \pm 23.7	33.5 \pm 12.2 ^{****}
No	76.5 \pm 19.6	41.9 \pm 38.1	56.9 \pm 22.7	56.4 \pm 18.6
Receive LTCI services				
Yes	68.8 \pm 26.4 [*]	45.0 \pm 38.0	61.9 \pm 23.2	57.2 \pm 20.3
No	76.8 \pm 18.0	39.8 \pm 38.9	52.9 \pm 23.3	52.2 \pm 20.0
Duration of care				
<5 hours/day	76.1 \pm 20.5	51.9 \pm 40.4 [*]	59.4 \pm 27.7	54.7 \pm 21.0
>5 hours/day	75.2 \pm 20.7	28.8 \pm 34.9	48.3 \pm 17.8	50.6 \pm 15.8
Relationship to care recipient				
Family caregiver	74.7 \pm 20.9	41.0 \pm 39.8	54.0 \pm 23.2	52.5 \pm 20.3
Spousal	75.7 \pm 20.0	45.8 \pm 43.1	59.1 \pm 28.5	59.1 \pm 21.0
Child	76.2 \pm 22.5	41.3 \pm 39.3	54.6 \pm 22.1	53.7 \pm 19.8
Daughter-in-law	71.4 \pm 18.0	38.9 \pm 42.2	50.4 \pm 24.6	46.8 \pm 21.2
Professional caregiver	84.2 \pm 8.6	41.7 \pm 25.8	51.7 \pm 16.7	58.3 \pm 9.7

Table 6 (Continued)

Parameters	PF	RP	BP	GH
Housing status				
Caregiver lives with recipient				
Yes	73.3 ± 22.0	39.4 ± 40.0	53.3 ± 22.9	49.9 ± 19.2
No	80.3 ± 15.5	48.7 ± 35.8	56.2 ± 23.5	59.6 ± 19.7
Recipient lives with:				
Biological child	73.3 ± 22.0	44.6 ± 38.7	55.6 ± 23.6	50.2 ± 18.0
Spouse	84.2 ± 1.20	58.3 ± 52.0	78.7 ± 24.4	65.7 ± 16.5
Multigenerational 2	78.1 ± 22.5	44.2 ± 38.4	52.5 ± 21.9	62.1 ± 20.1
Multigenerational 3	70.2 ± 16.4	25.0 ± 38.2	48.4 ± 25.2	40.9 ± 18.6**
Alone	72.5 ± 38.9	75.0 ± 35.4	81.0 ± 26.9	92.0 ± 0.0
Institution	79.6 ± 19.9	48.1 ± 40.1	57.2 ± 20.5	56.4 ± 16.3
Parameters	VT	SF	RE	MH
Caregiver details				
Caregiver age				
<65	55.5 ± 25.0	61.8 ± 26.9	60.8 ± 42.2	62.3 ± 21.2
>65	49.3 ± 22.1	58.0 ± 23.9	52.4 ± 43.8	59.1 ± 20.1
Caregiver gender				
Male	50.6 ± 18.4	60.2 ± 18.1	55.0 ± 46.6	60.6 ± 20.8
Female	63.0 ± 24.4	63.8 ± 26.3	60.0 ± 42.8	61.6 ± 21.1
Status of Care				
Receive care regularly				
Yes	50.9 ± 24.1 [†]	58.2 ± 25.5 [†]	53.6 ± 42.7	59.3 ± 21.3
No	67.8 ± 15.2	73.4 ± 17.0	80.0 ± 42.2	72.4 ± 11.6
Receive private services				
Yes	34.2 ± 24.9**	39.6 ± 30.1**	16.7 ± 32.4 [†]	46.0 ± 11.5**
No	56.3 ± 21.4	63.5 ± 22.3	61.8 ± 41.8	63.4 ± 20.9
Receive LTCl services				
Yes	59.5 ± 24.0	67.5 ± 23.7	64.3 ± 46.2	66.6 ± 21.5
No	51.5 ± 23.5	58.5 ± 25.5	53.7 ± 42.5	59.7 ± 20.6
Duration of care				
<5 hours/day	62.1 ± 22.8**	67.9 ± 22.9	72.9 ± 35.9**	66.0 ± 20.8**
>5 hours/day	44.5 ± 22.7	51.4 ± 25.1	41.4 ± 43.3	56.7 ± 20.0
Relationship to care recipient				
Family caregiver				
Spousal	52.9 ± 23.8	60.2 ± 25.1	56.9 ± 43.5	60.6 ± 21.3
Child	60.5 ± 31.6	75.0 ± 23.9	44.4 ± 45.5	71.7 ± 17.3
Daughter-in-law	53.3 ± 24.2	60.5 ± 24.0	58.1 ± 44.9	60.5 ± 23.2
Professional caregiver	49.2 ± 20.2	54.0 ± 27.0	57.9 ± 41.3	56.8 ± 17.0
Professional caregiver	45.0 ± 26.9	66.7 ± 29.2	50.0 ± 40.8	62.0 ± 18.0
Housing status				
Caregiver lives with recipient				
Yes	49.5 ± 23.4 [†]	57.3 ± 25.3 [†]	49.4 ± 42.0**	57.9 ± 20.5
No	57.4 ± 24.9	70.4 ± 24.4	78.9 ± 37.2	67.0 ± 21.5
Recipient lives with:				
Biological child	48.8 ± 23.5	57.9 ± 24.0	53.6 ± 44.8	61.5 ± 18.0
Spouse	78.9 ± 16.5	83.3 ± 14.4	44.4 ± 50.9	77.3 ± 20.5
Multigenerational 2	55.8 ± 20.0	53.9 ± 24.1	56.4 ± 41.7	60.5 ± 21.6
Multigenerational 3	47.9 ± 18.2	51.8 ± 27.4	54.2 ± 43.4	47.4 ± 18.5
Alone	90.0 ± 7.10	93.8 ± 8.8	100.0 ± 0.0	92.0 ± 5.7
Institution	48.5 ± 28.8	71.9 ± 25.6	61.5 ± 44.8	58.2 ± 25.3

Notes: Multigenerational 2: care recipient lives with children and grandchildren. Multigenerational 3: care recipient lives with children, grandchildren, and great-grandchildren.

Significance between the pairs above and below the asterisks:

[†] $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

**** $p < 0.0001$.

($p < 0.0001$) (Tables 4 and 6). More burdened caregivers reported lower BP, GH, VT, SF, and MH than less burdened caregivers ($p < 0.001$) (Table 4, Fig. 3B).

As detailed in Table 6, higher PF scores were exhibited by male caregivers ($p < 0.001$). Caregivers younger than 65 exhibited stronger PF ($p < 0.03$) and GH ($p < 0.01$). Interestingly, PF correlates with neither the level of care insurance status, J-ZBI,

BIC, GDS-5, nor BI. Caregivers residing with the care recipient experienced lower RE ($p < 0.006$). GH was strongest for caregivers of individuals who lived alone followed by caregivers who live with their spouse and was poorest for caregivers living in multigenerational housing ($p < 0.007$).

Although not statistically significant caregivers living in multigenerational housing also exhibited the lowest scores in

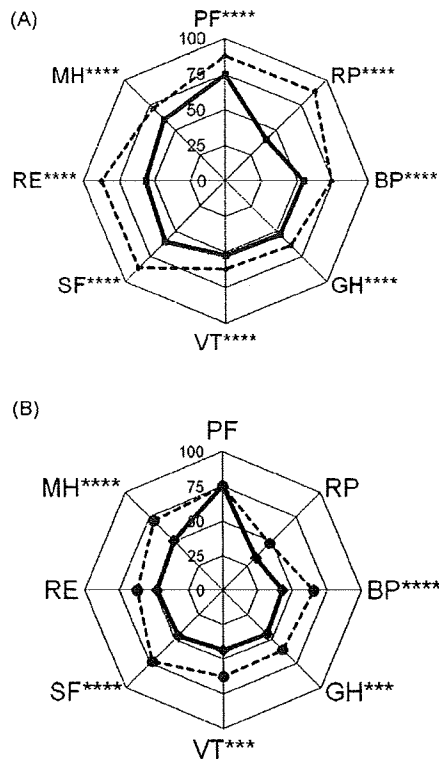


Fig. 3. Caregiver QoL. Part A compares total mean scores from this study (solid line) and total Japanese mean scores (dotted line) (Fukuhara and Suzukamo, 2004). Part B compares HRQoL mean scores for less burdened caregivers (J-ZBI mean score >36.39, dotted line) and more burdened caregivers (J-ZBI mean score <34.0, solid line) in the current study. Significance values **** $p < 0.0001$; *** $p < 0.001$.

PF, RP, BP, VT, SF, and MH (Table 6). Spousal caregivers reported the highest GH, VT, SF and MH. Daughter-in-law caregivers reported the lowest scores for all HRQoL SF-36 domains except for RE.

Caregivers who receive assistance from private services exhibit lower HRQoL scores in all domains, correlating significantly to GH ($p < 0.0001$) and VT, SF, RE, and MH ($p < 0.01$) (Table 6). Caregivers of recipients who receive care regularly reported lower VT and SF ($p < 0.05$) while caregivers providing care for more than 5 h per day reported less VT, RE, and MH ($p < 0.01$).

4. Discussion

This study provides the first in-depth look into the actual situation of informal caregivers of community dwelling elderly in Northern Japan with a specific focus placed upon caregivers of centenarians. The age of care recipients did not determine the level of burden experienced by the caregiver. Therefore, as elderly individuals advance in age they do not become a heavier burden on their familial caregivers. It cannot be concluded that caregivers of centenarians are models for successful caregivers as they did not experience less burden, higher QoL, or less prevalence of depression than control caregivers.

These results suggest that successful caregiving may be more strongly related to BP than age of the care recipient or perceptions of satisfaction from caregiving. Although many caregivers reported satisfaction in fulfilling their caregiving duty and filial piety obligations, those who cared for recipients with higher care needs levels were most likely to report pain from physically demanding forms of caregiving while those who cared for functionally independent care recipients reported lower levels of burden.

Caregiver quality of life scores are significantly lower than the general population signifying that all caregivers are experiencing stress and difficulties with providing care to their aging family member. As expected, this is exceptionally true for high burdened caregivers but surprisingly even less burdened caregivers report lower quality of life in all realms except for VT and MH which are close to expected levels. The low QoL scores for those receiving privately paid services may suggest the levels of support from LTCI services are not sufficient therefore there is a need to re-evaluate the LTCI support system to target more assistance to these informal caregivers. Since quality of life significantly correlates with caregiver burden, further study into the levels of burden as well as and examination of the root causes of stress and pressure in community caregivers is needed.

The present study indicated that caregivers of centenarians did not show significantly less burden, less prevalence of depression, or higher quality of life than caregivers of younger control recipients. Accordingly, this study is unable to confirm findings by Nishikawa et al. (2003) that caregivers of centenarians are models for successful care. Light and heavy caregiver burden was equally distributed among the three care recipient age groups highlighting that the older a care recipient becomes does not mean that they become heavier burdens on their caregivers.

It is traditionally viewed that multigenerational housing is a source of family strength and unity however this study found while 2nd multigenerational families including children and grandchildren showed low levels of caregiver burden 3rd multigenerational families which included children, grandchildren, and great-grandchildren showed the highest levels of caregiver burden. This may reflect increased stress from multiple caregiver demands associated with caring for aging parents as well as children and grandchildren.

Although employment is often perceived as an extra duty to add stress and burden to caregivers this study found that employment may serve as a source of strength, caregiver relief, and social network. The workplace and colleagues may provide a support system and an outlet for stress relief of informal caregivers as well as an opportunity for job satisfaction and independence.

Although traditionally the wife of the eldest son is expected to care for his aging parents the current study found males accounted for 12% of primary caregivers. Contrary to well-defined cultural roles of women as less burdened informal caregivers in Japan, this study revealed that male caregivers, all of whom were biological children, experienced lower levels of burden than female caregivers. Male caregivers reported significantly higher PF and less BP than female caregivers further supporting the hypothesis that burden is strongly associated with physically demanding caregiving.

In Japan, stigma towards receiving assistance from non-family caregivers, such as LTCI services or welfare services, and aversion towards admitting family members into long-term care facilities continues. Although some caregivers reported difficulty and frustration with caregiving, many described duty and pride in caring for their aging family member regardless of the pain or challenges it posed to them. In this study 23% of care recipients who do not have a care needs level receive care regularly which does not come from professional paid caregivers or services supported by LTCI suggesting that some informal caregivers may continue to feel uncomfortable to receive assistance from public services. Regardless of the functional ability of the care recipient, these caregivers reported the second lowest rates of caregiver burden behind caregivers of LTCI support care level recipients. Therefore, it is suggested that receiving assistance from LTCI and professional caregivers may not be the strongest variable associated with caregiver burden in Japan. These caregivers may represent traditional Japanese caregivers and therefore more study

is warranted to understand how these informal caregivers with no support from public services cope with the stresses and demands of caregiving.

This is the first study to report questionnaire data received from centenarians and control subjects residing in Sendai City, a medium sized city of approximately 1 million residents. The overall participation rate was expected due to multiple unavoidable factors including; the high mortality rate of centenarians, the possible inability of cognitively impaired elderly individuals to provide informed consent to their caregivers to complete the study on their behalf, difficulty in finding time to complete the questionnaire, and the slow updating of city registrars by Sendai City. The data gathered in this study may be limited in size and response rate however they are an invaluable resource as this is the first study to provide insight into the situation of centenarians and their caregivers in Sendai city, Northern Japan. Citizens in Northern Japan differ greatly in daily lifestyle, attitudes, and thinking from those residing in Metropolitan Tokyo or the southern Island of Okinawa. This is an excellent opportunity to increase understanding of informal caregivers of community dwelling elderly and the burdens the caregivers face under the new LTCI program.

This present study is distinct from the published literature because it focuses specifically upon the situation of caregivers of centenarians. Minimal research exists focusing upon these caregivers who represent a unique group of aging caregivers who care for recipients with exceptional longevity. Due to the rising number of centenarians and growing demands on the health care system, understanding the role of the unpaid informal family caregiver will become more important in the future.

5. Conclusion

This population based self-reporting questionnaire study examined the caregiving burden for the oldest old with a specific focus on caregivers of centenarians. Caregivers of centenarians did not report significantly lower levels of caregiver burden, higher prevalence of depression, or higher quality of life than caregivers of controls therefore it cannot be concluded that caregivers of centenarians are models for successful caregivers. Moreover, this study found that as care recipients age they do not inevitably become larger burdens on their caregivers. Informal unpaid community dwelling caregivers of the oldest old may play an important role in the economic survival of the health care system in the future. Therefore, by understanding the feelings of caregivers and the health needs of centenarian care recipients, government officials can target future health care services to prepare for the needs of this growing population. Further investigation of caregiver burden of the oldest old should focus upon the

relationship between actual physical level of duties performed by the caregiver and the physical stress, pain, and exhaustion they experience.

Conflict of interest statement

None.

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Effect of Radiation Monitoring Method and Formula Differences on Estimated Physician Dose during Percutaneous Coronary Intervention

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Chida K, Morishima Y, Masuyama H, Chiba H, Katahira Y, Inaba Y, Mori I, Maruoka S, Takahashi S, Kohzuki M, Zuguchi M. Effect of radiation monitoring method and formula differences on estimated physician dose during percutaneous coronary intervention. *Acta Radiol* 2009;50:170–173.

Background: Currently, one or two dosimeters are used to monitor radiation exposure in most cardiac laboratories. In addition, several different formulas are used to convert exposure data into an effective dose (ED).

Purpose: To clarify the effect of monitoring methods and formula selection on the estimated ED for physicians during percutaneous coronary interventions (PCIs).

Material and Methods: The ED of physicians during cardiac catheterization was determined using an optically stimulated luminescence dosimeter (Luxel badge). Two Luxel badges were worn: one beneath a personal lead apron (0.35-mm lead equivalent) at the chest and one outside of the apron at the neck.

Results: The difference in the average ED of seven physicians was approximately fivefold (range 1.13–5.43 mSv/year) using the six different formulas in the clinical evaluation. The estimated physician ED differed markedly according to both the monitoring method and formula selected.

Conclusion: ED estimation is dependent on both the monitoring method and the formula used. Therefore, it is important that comparisons among laboratories are based on the same monitoring method and same formula for calculating the ED.

Key words: Angioplasty; catheterization; coronary intervention; interventional; radiation exposure; radiation safety

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During complex cardiac intervention procedures such as percutaneous coronary intervention (PCI), both the patient and physician receive high doses of radiation (1–12). Physicians have been injured performing some fluoroscopically guided intervention procedures; e.g., cataract has been reported to develop (9). The problem of higher scattered doses to physicians owing to their proximity to the patient

is compounded by the extended fluoroscopy required in some interventional radiology procedures, as in PCI.

The most important method of evaluating the radiation dose received by the physician is the use of robust radiation monitoring methods, such as film badges and thermoluminescent dosimeters. Generally, a single dosimeter worn under a lead apron will

yield a reasonable estimate of the effective dose (ED). However, in catheterization laboratories, it is recommended that the physician wear two monitors: one under the lead apron at waist level and one outside the lead shield at the collar (13). Nevertheless, many laboratories use a single dosimeter only. Furthermore, dosimeters worn outside the lead apron are important for monitoring the radiation dose to parts of the body that are not protected by the lead apron, especially hands and the lens of the eye.

It is unclear how accurately these two monitoring methods detect the estimated physician dose during fluoroscopically guided intervention procedures. In addition, several different formulas are used to convert exposure data into an ED. Therefore, this study examined the estimated physician dose (i.e., ED) during fluoroscopically guided intervention procedures using one or two dosimeters.

Material and Methods

Two monitoring methods were evaluated: the use of one versus two optically stimulated luminescence dosimeters (Luxel badge; Landauer Inc., Glenwood, Ill., USA). Fig. 1 indicates the position of each dosimeter during estimation of the ED.

Two dosimeters

The ED was calculated using one of the following three equations:

$$ED = 1.5H_{in} + 0.04H_{out} \quad (1)$$

$$ED = 0.5H_{in} + 0.025H_{out} \quad (2)$$

$$ED = 0.89H_{in} + 0.11H_{out} \quad (3)$$

where H_{in} is the dose received by the chest or waist dosimeter under the lead apron, and H_{out} is the dose received by the neck (collar) dosimeter outside the lead apron. Formulas 1–3 are based on methods recommended by the National Council on Radiation Protection (NCRP) (14) and the American College of Cardiology (ACC) (13), Baim et al. (12), and the Radiation Council of the Ministry of Japan (modified) (15).

One dosimeter

The ED was determined using one of the following three equations:

$$ED = H_{out}/5.6 \quad (4)$$

$$ED = 0.3H_{out} \quad (5)$$

$$ED = H_{in} \quad (6)$$

Formulas 4 and 5 were used to calculate the ED according to the methods described by the NCRP

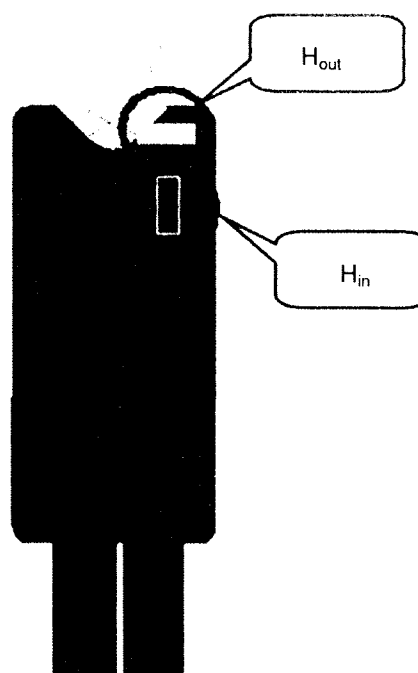


Fig. 1. Positions of the dosimeters used to measure H_{in} and H_{out} during percutaneous coronary intervention. These values were used to estimate effective dose (ED). H_{in} : dose received by the dosimeter worn under the lead apron at the chest; H_{out} : dose received by the dosimeter worn outside the lead apron at the neck.

(14) and Baim et al. (12), respectively; formula 6 is a general method for a single dosimeter.

Outside/behind ratio (OBR)

The doses received by physicians will differ for exposed and protected parts of the body (i.e., the doses recorded inside and outside the apron), since a shielded dosimeter receives a much lower dose than an exposed dosimeter. To account for these differences, the outside/behind ratio (OBR) for the radiation dose was determined using the formula $OBR = H_{out}/H_{in}$. When the OBR is large, the physician dose is considered non-uniform, whereas a value of 1 indicates a uniform dose to the entire body.

Clinical evaluation

The annual ED for physicians during cardiac catheterization procedures (including PCI) in Tohoku Employees' Pension Welfare Hospital was determined using Luxel badges. Approximately 300 PCI procedures are performed at this institution annually. In this study, percutaneous entry via the

Table 1. Outside/behind ratios (OBRs) calculated for each of the seven physicians monitored

Physician no.	Annual data			
	No. of PCIs	H _{in} , mSv	H _{out} , mSv	OBR (H _{out} /H _{in})
1	42	0.19	11.48	60.42
2	66	0.76	17.33	22.80
3	77	1.24	22.02	17.76
4	104	2.43	18.52	7.62
5	82	1.13	22.41	19.83
6	67	0.64	12.66	19.78
7	107	2.44	22.23	9.11

PCI: percutaneous coronary intervention; H_{in}: dose received by dosimeter worn under lead apron at the chest; H_{out}: dose received by dosimeter worn outside lead apron at the neck.

femoral artery was the most common approach to PCI.

A digital cine single-plane angiography unit (KXO-80c; Toshiba, Tokyo, Japan) with an under-table X-ray tube system was used. Digital cine acquisition was performed at 30 frames/s during each procedure. Pulsed fluoroscopy (30 pulses/s) and a 17-cm mode image intensifier with an X-ray grid were also used. The manufacturer serviced the X-ray equipment at least twice a year.

Each physician wore two Luxel badges: one under a personal lead apron (0.35-mm lead equivalent) at the chest and one outside the apron at the neck. The radiation exposure of physicians during cardiac catheterization was evaluated from 2002 to 2005. Each of the seven physicians examined in this study performed 77.8 ± 22.7 (average \pm SD; range 42–107) (Table 1) PCI procedures annually, and the physicians were required to attend a radiation safety course once a year. The calculated annual values for ED and OBR were compared among the seven subjects.

Results

The average OBR was 22.5 ± 17.7 (range 7.6–60.4) (Table 1). Table 2 shows the annual EDs obtained for each of the seven physicians using formulas 1–6. The difference in the average ED of the seven physicians was approximately fivefold using the six different formulas in the clinical evaluation, ranging from 1.13 to 5.43 mSv/year with formulas 2 and 5, respectively. These values differed markedly according to the monitoring method (one versus two dosimeters) and the formula used to calculate the ED.

Discussion

In the clinical evaluation, the OBR of physicians during cardiac catheterization was approximately 20 (range 7.6–60.4). This finding is noteworthy, because the OBR of physicians in catheterization laboratories has not been previously determined. In addition, the difference in ED was approximately fivefold using the six different formulas in the clinical evaluation. Therefore, even if the same monitoring method were used to measure physician dose, the ED may still differ depending on the formula selected to calculate the ED. For this reason, it is important that comparisons among laboratories are based on the same monitoring method and same formula for calculating the ED.

This study could not determine which formula is best. In addition, the OBR values were inconsistent and were dependent on the procedural circumstances. However, this study indicates that the two-dosimeter method may be best for estimating the ED during interventional radiology procedures, given that the dose to the physician during these

Table 2. Effective doses (EDs) obtained using formulas 1–6 for each of the seven physicians monitored

Physician	Effective doses (ED, mSv)						Max./min. ED among six formulas
	Formula						
	(1)	(2)	(3)	(4)	(5)	(6)	
1	1.54	0.51	6.54	2.05	3.44	0.19	34.42
2	2.41	0.91	6.30	3.09	5.20	0.76	8.29
3	3.04	1.22	5.47	3.93	6.61	1.24	5.41
4	4.39	1.68	4.20	3.31	5.56	2.43	3.31
5	2.59	1.13	3.47	4.00	6.72	1.13	5.95
6	1.60	0.66	2.82	2.26	3.80	0.64	5.93
7	4.55	1.78	4.62	3.97	6.67	2.44	3.76
Average \pm SD	2.87 ± 1.21	1.13 ± 0.48	4.77 ± 1.40	3.23 ± 0.82	5.43 ± 1.37	1.26 ± 0.87	4.82

procedures differs on the exposed and protected parts of the body (i.e., inside and outside the apron). In addition, dosimeters worn outside the lead apron are important for monitoring the radiation dose to parts of the body that are not protected by the lead apron. Furthermore, if the radiation doses to the hands or lens of the eye differ from H_{out} , the ED will have a different value.

During a clinical evaluation, the physicians used additional lead shielding devices. In the absence of additional shielding devices, H_{out} would be larger, because these devices shield parts of the body that are not protected by the lead apron, leading to increases in OBR and subsequent increases in ED.

In conclusion, physicians receive non-uniform doses of radiation (i.e., the dose to exposed and protected parts of the body differs) during PCI. The ED depends on the monitoring method (one versus two dosimeters) and the formula selected for calculating the ED. Therefore, it is necessary to use the same monitoring method and formula when comparing ED data among laboratories.

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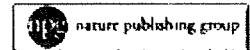
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Combination of chronic exercise and antihypertensive therapy enhances renoprotective effects in rats with renal ablation.

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Abstract

BACKGROUND: We assessed the renal protective effects of treatment with moderate exercise (EX), with EX plus olmesartan (OLS), with EX plus azelnidipine (AZN), and with the three together in a rat model of chronic renal failure (CRF). **METHODS:** Male 5/6-nephrectomized Wistar Kyoto (WKY) rats were divided into six groups according to the following treatments for: (i) no EX (C); (ii) moderate EX with treadmill running (20 m/min for 60 min/day, 5 days/week) (EX); (iii) EX+OLS (10 mg/kg/day); (iv) EX+AZN (3 mg/kg/day); (v) EX+OLS (5 mg/kg/day)+AZN (1.5 mg/kg/day); and (vi) sham operation (S). The rats were then treated for 12 weeks. **RESULTS:** EX, EX+OLS, EX+AZN, and EX+OLS+AZN showed decreases in the serum creatinine (Scr), an index of glomerular sclerosis (IGS), the relative interstitial volume of the renal cortex (RIV), the number of ED-1 (monoclonal antibody) positive cells (ED1(+)) and the glomerular expression score of alpha-smooth muscle actin (alpha-SMA(+)). EX+OLS, EX+AZN, and EX+OLS+AZN blocked the development of hypertension, increased the number of Wilms' tumor-1 (WT-1) positive cells (WT1(+)); EX+OLS and EX+OLS+AZN blunted the increases in proteinuria. In particular, blood urea nitrogen (BUN), ED1(+), alpha-SMA(+), WT1(+), IGS, and RIV in the EX+OLS+AZN were the lowest among all the nephrectomized groups. **CONCLUSIONS:** In the results, simultaneous treatment of EX, OLS, and AZN showed renal protective effects in this rat model suggesting that the treatment may affect the macrophage infiltration to the glomerulus, the fibroblast accumulation in the glomerulus, the mesangial activation, and the podocyte differentiation.

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Understanding the oldest old in northern Japan: An overview of the functional ability and characteristics of centenarians

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Aim: To increase knowledge of the functional ability of centenarians by examining the situation of Japanese centenarians residing in an urban region in northern Japan.

Methods: Questionnaires focused on functional ability, demographics, housing and care needs were received from 56 centenarians and 104 control subjects: 56 aged 80–89 and 48 aged 90–99.

Results: Centenarian physical capabilities, care needs and health history were diversified. Centenarians most commonly resided with family in the community and were likely to utilize informal and insurance care services. Gender differences in functional ability by age groups known as gender cross-over were observed in control subjects but reduced in centenarians. A few who reported physical limitations were not entitled to receive nationally subsidized care services suggesting inaccuracies may have occurred during certification determination.

Conclusion: Centenarians in northern Japan represent a heterogeneous cohort suggesting multiple paths to the attainment of advanced old age. This is the first study designed to provide a solid knowledge base of actual circumstances experienced by centenarians specifically in northern Japan. *Geriatr Gerontol Int* 2010; 10: 78–84.

Keywords: aged, aging, health services for the aged, health status, gender characteristics.

Introduction

Japan, a nation famous for longevity, is one of the fastest graying nations in the world. The Japanese population aged over 65 will rise from 20.1% in 2006 to 26% by 2015 and 30.9% by 2030.¹ The number of centenarians in Japan in 2005 was 25 554, 85.2% being female, and is projected to increase to over 166 000 by 2025.¹ With continuous developments in medical care, people are

expected to live longer while the prevalence of individuals living with disabilities and or diseases requiring care is also anticipated to increase.

Due to the historical stigma towards institutionalized care combined with the lack of adequate long-term care facilities, many elderly people were hospitalized for long periods of time in regular hospitals.² Long-Term Care Insurance (LTCI) introduced in Japan in April 2000 aimed to increase home care services, reduce the number of hospitalizations and unnecessary medical expenses, and increase support to the elderly and their burdened caregivers.

Centenarians represent a heterogeneous cohort and require a diverse range of care from informal and formal care services. By understanding the strengths and weaknesses of LTCI and its utilization by centenarians in

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