ORIGINAL ARTICLE

ACTIVE LIFE EXPECTANCY OF THE ELDERLY POPULATION IN A CITY OF THE TOHOKU DISTRICT IN JAPAN

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Objective: The purpose of this study was to determine the active life expectancy (ALE) of residents aged 65 and older from a city of Tohoku District in Japan based on changes in their Activities of Daily Living (ADL) over the course of three years, taking into account the ADL functional recovery rate. **Methods:** According to the method of Andrei Rogers, et al., the survey was conducted twice using a questionnaire covering questions as to ADL independence. The life table was prepared based on the transition probability of ADL by age for the subject populations to determine the average life expectancy and ALE. **Results:** Among the independent persons surveyed first, the average life expectancy was 18.7 and 23.5 years for 65-year-old males and females, respectively. When the ADL functional recovery rate was taken into account, the ALE stood at 17.2 and 20.7 years for males and females at the age of 65, respectively. Assuming that the difference between the average life expectancy and ALE represents the duration of dependence, it was calculated to be 1.5 and 2.8 years for 65-year-old males and females, respectively. **Conclusion:** Comparison of the average life expectancy and ALE with other areas already reported revealed that the inhabitants of the city studied had a long average life expectancy and ALE, and a comparatively short duration of dependence.

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原　著

東北地方の一都市における65歳以上の活動的平均余命

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抄録　この研究の目的は，北東北地方の一都市における 65 歳以上の地域住民の活動的平均余命を，機能回復率を考慮し，3年後の日常生活動作（Activities of Daily Living）の変化をもとに明らかにする事である．調査方法は Andrei Rogers らの方法に従い，ADL の自立の有無を問う質問項目を含む質問紙調査を 2 回行った．対象の ADL の年齢別移行確率をもとに生命表を作成し，平均余命と活動的平均余命を求めた．1 回目の調査時の自立者の平均余命は，65 歳の男性 18.7 年，女性 23.5 年であった．活動的平均余命は，ADL の機能回復率を考慮すると 65 歳の男性 17.2 年，女性 20.7 年であった．それぞれの平均余命と活動的平均余命の差を要介護期間とすると，65 歳の男性 1.5 年，女性 2.8 年であった．平均余命，活動的平均余命を他市の報告と比較すると，H市は，平均余命，活動的平均余命共に長く，要介護期間はそれに比較して長くはないと言える．

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Introduction

With an average life expectancy of 85.33 years for females and 78.36 years for males, as estimated from the 2004 Abridged Life Table[1], the Japanese population is recognized as one of the longest living in the world. As people live longer, they increasingly suffer from lifestyle-related diseases, aging-related disorders and conditions such as dementia, or may become bed-ridden. While the average life expectancy has frequently been used as an index for the health status of a population in a particular region, an alternative index is required to take quality of life into consideration. The active life expectancy (ALE) provides such an index, and can be estimated from the mortality table[2]. The ALE is a measure of the age to which people live in good health, indicating the length of an independent life in which no support for daily activities is required. There are many reports regarding ALE concepts and calculation approaches[3-11].

Katz and colleagues[2] introduced a life-table analysis to demonstrate the ALE concept. In this analysis, life-table techniques are used to determine an expected value for the period of well-being, using activities of daily living (ADL), such as eating, dressing and bathing and movement, to represent functional status. However, this life-table analysis does not take the functional recovery rate into consideration in ALE. Hence, even if a person receives support at some point in time, the possibility remains that they can recover their functional independence; therefore, the calculation of the ALE should include the functional recovery rate to be more consistent with the actual situation. Rogers et al.[3] developed a multi-state analysis method (the so-called increment-decrement life-table method), in which the ALE is computed with consideration of the functional recovery rate, using four ADL variables of Katz Index. The majority of researchers of ALE now utilize the increment-decrement life-table method.

Several reports on ALE in communities in Japan have been published[12-20], but different indicators for definition of health status and different approaches to measurement of ALE were used in these studies. Hence, the ALE values obtained were dependent on the particular health-status indicators used in the determination of the ALE. Furthermore, since few of these studies took the functional recovery rate into consideration, it is likely that the reported ALE values are shorter than the true values. These limitations make it difficult to compare the values directly with each other and with ALE values determined in international studies.

Given the above background, we studied Japanese ALE by application of the Rogers multi-state analysis method, as a follow up to our community ALE study using the Katz index for health status and the functional recovery rate over the course of one year[21]. The current study was a longitudinal study, which targeted people in a city in northern Japan who were 65 years old and older the beginning of the study, with the aim of determining their ALE based on ADL changes over the course of three years.

Study Methods

The survey was conducted twice using a questionnaire, according to the method of Rogers et al.[3]. Questions were designed to determine the independence in ADL of the subjects to allow an estimate of the length of their independent life. In the first survey, performed in 1998, the questionnaires were distributed to all local residents of the city who were over the age of 65. The second

survey, in 2001, only targeted surviving residents who had completed the first questionnaire. In requesting participation in the survey, informed consent was obtained based on specification of the study objectives, the voluntary nature of participation, and that the data would be used exclusively for the stated objectives. Contact information for the surveyors was also given. Independence in ADL was defined as independence in all four categories (bathing, clothing, eating and movement), based on the criteria of the Katz index.

Of 31,674 residents in H City (as the city will be referred to hereafter) over the age of 65 as of August 1998, 31,090 were surveyed during the period from October to December, 1998. Those who had died or moved to another city or whose address was unknown at the time the questionnaire was sent were excluded from the study. Questionnaires were distributed either directly or by mail, with a request to return them on survey completion. When individuals were unable to complete the survey independently, a family member or caregiver was asked to complete it. For residents in specialized nursing homes, questionnaires were delivered directly to the facility and collected upon completion. 18,148 people responded to the first questionnaire, giving a response rate of 58.4%.

The second survey was conducted during the period from October to December, 2001. Of the 18,148 respondents to the first survey, 4,884 who did not satisfactorily complete the first questionnaire and 1,129 who died thereafter were excluded; the remaining 12,135 respondents were surveyed using the second questionnaire, which was distributed either directly or by mail. 9,985 responses to the second questionnaire were received, but some respondents gave insufficient information, resulting in valid responses from 4,091 males and 5,029 females, for a total of 9,120 people.

Statistical analysis was performed on the data from the 9,120 respondents who gave sufficient information on both questionnaires and on the 1,129 respondents (577 males and 552 females) who completed the first questionnaire and then died in and after 1998, for a total sample size of 10,249 people. The life table was prepared based on the transition probability by age and sex for the following populations to determine average life expectancy and ALE: ADL-independent persons in the first survey who became ADL-dependents in the second survey; ADL-independents in the first survey who died thereafter; ADL-dependents in the first survey who became ADL-independents in the second survey; and ADL-dependents in the first survey who died thereafter. The functional recovery rate, defined as the percentage ratio of the number of ADL-independent persons in the second survey to the number of ADL-dependent persons in the first survey, was taken into consideration in the calculation of the ALE. However, the persons of 90 years and more were treated as one group, because the sample number was small. The mortality and the shift rate of ADL-independent persons to an ADL-dependent condition, and the functional recovery rate of ADL-dependent persons to an ADL-independent condition were calculated as values per year. A χ^2 test was conducted to compare the functional recovery rates for male and female subjects.

Results

Characteristics of subjects

The subject breakdown by sex and age is presented in Table 1. Of all the questionnaires, 79.8% were filled out by the subjects, 16.6% by a family member, and 3.6% by an acquaintance or others. Among 9255 ADL-independent persons in the baseline (first) survey, 580 were ADL-dependent in the second survey, and 693 had died since the baseline survey (Table 2). Among 994 ADL-dependent persons in the first survey, 149 were ADL-independent in the second survey, and 436 had died since the baseline survey. Among ADL-dependent persons in the first survey, 149 were ADL-independent persons in the second survey. The functional recovery rate were 16.4% and 14.2% for males and females, respectively.

Table 1 Numbers of the subjects by sex and age

Age	Male	Female	Total
65~69	1,812	1,806	3,618
70~74	1,494	1,496	2,990
75~79	735	991	1,726
80~84	375	674	1,049
85~	252	614	866
Total	4,668	5,581	10,249

Table 2 Changes of the ADL status from 1998-2001

1998				2001			
No. of persons					No. of persons		
	Male	Female	Total		Male	Female	Total
				Independent	3,716	4,266	7,982
Independent	4,327	4,928	9,255	Dependent	216	364	580
				Death	395	298	693
				Dependent	103	306	409
Dependent	341	653	994	Independent	56	93	149
				Death	182	254	436

Average Life Expectancy and ALE

The average life expectancies for ADL-independent persons in the first survey were 18.7 and 23.5 years for 65-year-old males and females, respectively, and 8.7 and 11.9 years for 80-year-old males and females, respectively. For ADL-dependent persons in the first survey, these numbers were 6.8 and 11.2 years for 65-year-old males and females, and 4.1 and 6.5 years for 80-year-old males and females (Table 3). The differences in average life expectancy between ADL-independent persons and ADL-dependent persons were 11.9 and 12.3 years for 65-year-old males and females, and 4.6 and 5.4 years for 80-year-old males and females.

When the functional recovery rate in ADL was taken into account, the ALE was 17.2 and 20.7 years for 65-year-old males and females, respectively, and 8.4 and 11.1 for 80-year-old males and females,

respectively. Assuming that the difference between average life expectancy and ALE represents the duration of dependence, this was calculated to be 1.5 and 2.8 years for 65-year-old males and females, and 0.3 and 0.8 years for 80-year-old males and females. If the functional recovery rate was omitted from this calculation, the ALE was 16.5 and 19.2 years for 65-year-old males and females, respectively, and 8.1 and 10.5 for 80-year-old males and females, respectively. Hence, inclusion of the functional recovery rate made a difference in ALE of 0.7 and 1.5 years for 65-year-old males and females, respectively, and 0.3 and 0.6 for 80-year-old males and females, respectively. ALE including the functional recovery rate accounted for 92.0 % and 88.1% of the average life expectancy for 65-year-old males and females, and 96.6% and 93.3% for 80-year-old males and females, respectively.

Table 3 The estimated life expectancy for the study population in 1998, and ALE of ADL- independent persons in 1998, with or without adjustment of functional recovery rates

Item	Male					Female				
Age (years)	65	70	75	80	85	65	70	75	80	85
Life expectancy of										
All persons (years)	16.7	13.2	9.9	7.1	5.4	20.8	16.7	12.9	9.5	7.0
ADL-independent persons (years)	18.7	15.1	11.7	8.7	7.2	23.5	19.3	15.5	11.9	9.1
ADL-dependent persons (years)	6.8	5.7	4.9	4.1	3.3	11.2	9.6	8.1	6.5	5.3
ALE of independent persons										
with adjusted functional recovery rates (years)	17.2	14.2	11.2	8.4	7.2	20.7	16.9	13.8	11.1	9.0
without adjusted functional recovery rates (years)	16.5	13.5	10.7	8.1	7.1	19.2	15.8	13.0	10.5	8.7

ALE: Active Life Expectancy.

Table 4 shows the functional recovery rates stratified by 5-year age groups over a 3 year period. Comparison of these data between males and females showed that the functional recovery rate for females aged 65-69 was significantly higher than that of males (p<0.05). However, the functional recovery rate showed a tendency to decrease with age in both males and females.

Discussion

The study produced the ALE based on three-year of observation, taking into account the functional recovery rate and applying the same ADL indicators to assess independence that were utilized by other countries' reports. The ALEs of males and females aged 65 years old in H City in the baseline survey were 17.2 and 20.7 years, respectively, which were longer than the ALE of residents in three cities (Boston, New Haven and Iowa) in the United States, as reported by Branch[4] (males and females aged 65: longer by 4.3-5.9 and 3.6-5.3 years, respectively; and also longer

for males and females aged 75 and 85). The life expectancy of independent persons in the baseline survey was also longer than those in the three cities, similarly to the ALE (males and females aged 65: longer by 2.0-5.5 and 2.1-5.0 years, respectively; and also longer for males and females aged 75 and 85). To compare the ALE without the difference in life expectancy, the ratio of ALE to life expectancy (the ALE ratio) was calculated. The ALE ratios of males and females aged 65 in this study were the highest in male and 2nd in female (male: 92.2%; female: 88.0%) among those in four cities. We note that these studies were carried out in different years (18-year difference) and the comparison of the results should be viewed in this context; however, the life expectancy and ALE of residents in H City were the longest and the ALE ratio was high one in these four cities.

The ALE obtained for H City is not strictly comparable with other local ALE values determined in Japan, because different

Table 4 Functional recovery rate: ADL- dependent persons in 1998 who became ADL -independent persons in 2001

Age	65~69	70~74	75~79	80~84	85~	Total
Male						
(a) Number of those who were dependent persons in 1998	62	74	74	58	73	341
(b) Number of those who recovered in 2001 among (a)	14	17	15	7	3	56
Recovery rate {(b)/(a)×100} (%)	22.6	23.0	20.3	12.1	4.5	16.4
Female						
(a) Number of those who were dependent persons in 1998	56	76	116	152	253	653
(b) Number of those who recovered in 2001 among (a)	24	28	16	18	7	93
Recovery rate {(b)/(a)×100} (%)	42.9	36.8	13.8	11.8	2.8	14.2

definitions of independence have been used to derive the ALE values. The ALE in Saku City (Nagano Prefecture)[20] has been reported to be 16.0 and 18.9 years for 65-year-old males and females, respectively, and 5.1 and 6.5 years for 80-year-old males and females, respectively. The definition of independence in the Saku City study used five items (bathing, changing clothes, using the rest room, standing up, and eating), whereas only four items were used in the current study. Therefore, it is likely that ALE in the Saku City study was underestimated, compared to our study. Moreover, the ALE among citizens of Sendai[12] has been reported to be 13.2 and 16.0 years for 65-year-old males and female, respectively, and 4.7 and 5.6 years for 80-year-old males and female, respectively. Compared with Sendai City, ALE in H City is 3.8 to 7.0 years longer for 65- to 80-year-old males, and 3.7 to 4.7 years longer for 65- to 80 year-old females. ADL (bathing, dressing, toileting, and eating) was used in the definition of independence in the Sendai study, rather than the Katz index, and this difference seems to have influenced the ALE values. The difficulty in making comparisons between studies suggests that uniform indices should be used in future evaluations of ALE.

The ALE calculated with inclusion of functional recovery rate was longer for males and females by 0.7 and 1.5 years at the age of 65 and by 0.3 and 0.6 years at the age of 80 in the baseline survey, compared to the ALE calculated with omission of the functional recovery rate. A difference of greater than one year was apparent in females at the age of 65, and therefore the design and conduct of healthcare and welfare measurements of ALE that include functional recovery rate is practical and useful for making cost-effective human resources decisions.

In a comparison between males and females in H City, both life expectancy and ALE were longer in females than males, and the period for which care was needed was approximately double for females, compared to that for males. Other studies have also indicated that females require a longer period of care[4,11]. The difference in the period of required care may depend on differences in smoking, exercise and eating habits[22] and diseases (males tend to have heart disease, whereas females tend to have knee-joint diseases)[23]. In this study, the lifestyle, cause of death and diseases and morbidity in subjects were not specified, and therefore the reasons for the difference in the period of required care cannot be explained in detail.

The estimated ALE was compared with the life expectancy of independent subjects in the study, rather than with the life expectancy of all subjects in the baseline survey, for the following reason. The ALE was obtained for all subjects in the baseline survey, but an ALE of 0 was calculated for a person who required care in the baseline survey and was still in this situation in the second survey. Therefore, the ALE from the second survey is only applicable for independent people in the baseline survey and people in need of care on the first survey who recovered to an independent condition.

The functional recovery rates over 3 years of all subjects in H City were 16.4% in males and 14.2% in females. In a study in Saku City (Nagano Prefecture, Japan)[14], the ADL indices used to evaluate independence and the observation period differed from those used in our study. However, the functional recovery rates over one year were 14% in males and 12% in females, which are similar to our results. In contrast to these results, Katz et al.[2], found a functional recovery rate of 24% over 16 months.

No significant differences in the mean functional recovery rate were found between males and females of all ages, but a comparison of the functional recovery rates stratified by 5-year age groups suggested a significantly higher functional recovery rate for females aged 65-69, compared to that of males (p<0.05). We note that a study using a different definition of independency in ADL showed that the functional recovery rate of males was higher than that of females[24]. Although the increased functional recovery rate for females aged 65-69 is of interest, the reasons for this increase require further investigation.

Comparison between 1-year and 3-year periods

In our previous study[21], ALE was estimated from changes in ADL after one year, whereas in the current study shift rates to an ADL-dependent condition were investigated after 3 years. Comparison of the results of the two studies showed similar tendencies, but the life expectancy of persons in need of care and the ALE of independent persons without consideration of functional recovery rate were 2 years longer in the current study. This difference between the same subjects depended on differences in the mortality and incidence of functional disorders that reduced independence. The mortality rates of persons who were in need of care in the baseline survey were 28.1% in males and 17.6% in females after one year, but 17.8% in males and 13.0% in females after 3 years. The incidences of disorder in independent persons were 3.3% in males and 4.2% in females one year later, but 1.7% in males and 2.5% in females 3 years later.

The life expectancy of ADL-dependent persons was longer in our study, due to the lower mortality rate. Lower mortality rates and a lower incidence of disorder in independent persons also accounted for the higher ALE of ADL-independent persons in our study, without consideration of functional recovery rate. However, it is unclear why the mortality and incidence of disorders were lower over a 3-year period, therefore further studies of this issue are required. The functional recovery rates were 21.3% in males and 15.9% in females after one year, but 16.4% in males and 14.2% in females after 3 years. Hence, the functional recovery rates in the current study were slightly lower, suggesting that subjects showed a high rate of functional recovery within one year, but then tended to redevelop functional disorder after one year.

Limitations of the study

The data collection rates were 58.4% and 82.3% in the first and second surveys, respectively. There were many non-responders and responders who provided invalid answers, and this may have had some effect on the ALE estimation. However, the ratio of responders with valid answers was 23.3% and this number did not change with respect to age and sex. According to the Life tables by municipality 2000[25], the life expectancy for H City was 16.3 years for males and 21.5 years for females at the age of 65 and 7.1 for males and 9.7 years for females at the age of 80, which were similar to the life expectancies estimated in this study. Since there was no difference in age for responders with invalid answers, these results indicate that age and sex biases were not induced by the large number of non-responders and responders who gave invalid answers.

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