

Aging Gracefully: A Retrospective Analysis of Functional Status in Okinawan Centenarians

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Objective: *This study retrospectively explored the late-life functional status of Okinawan centenarians.*

Methods: *Activities of daily living were measured retrospectively at five time points (10, 5, 3, and 1 year prior and present) for 22 centenarians in relation to seven physical, two sensory, and two cognitive functions using the Inoue Index. Results:* *In all, 82% of individuals were still functioning independently at a mean age of 92 years and almost two-thirds were still functioning independently at a mean age of 97 years.*

Conclusion: *Preliminary analyses suggest high functional status in Okinawan centenarians throughout their 90s. The genetic and environmental factors contributing to this successful aging phenomenon deserve further investigation. (Am J Geriatr Psychiatry 2007; 15:252-256)*

Key Words: ADL, functional status, centenarians, Okinawa, successful aging

Understanding the functional characteristics of exceptionally long-lived individuals has recently become an important focus of gerontology research. However, despite growing research on the

levels of disability among the oldest old (aged 85 years and older), we still have very little knowledge of the disability process and there is a similar dearth of knowledge regarding the functional status of exceptional survivors, such as centenarians—particularly with regard to centenarians in nonwestern settings.

Although far from complete, recent work is beginning to rectify this problem. For example, centenarian veteran enrollees in the United States have been found to have significant physical limitations despite a reported low number of age-associated diseases.¹ In addition, a significant north-south gradient in handgrip strength in centenarians (and nonagenarians) in three European regions was recently reported, highlighting regional differences in functional status among the oldest old.²

Do autonomous centenarians exist? How we define autonomy will, in large part, determine our answer to this important question. Moreover, the existence of a wide range of heterogeneity in functional status has been a commonly reported research finding in previous studies of the oldest old. Defining autonomy as living at home, being relatively activities of daily living (ADL)-independent and cognitively intact, Andersen-Ranberg et al. found 12% of Danish centenarians to be autonomous.³ Following this, Motta et al. examined physical (ADLs) and cognitive (Mini-Mental State Exam [MMSE]) status in 602 centenarians subjects of the Italian Multicenter Studies on Centenarians and found 20% of centenarians to be in “good health status.”⁴ Gondo et al. reported similar numbers (18%) of Japanese centenarians in Tokyo to be exhibiting “normal” physical or cognitive functions (some deficits in ADLs), with another 2% defined as “exceptional” (all functions graded as “excellent”).⁵

These recent studies have all attempted to characterize the functional status of centenarians and have found, not surprisingly, high levels of disability in these exceptional survivors with only a minority that could be characterized as “independent” in their activities of daily living. However, we could find only

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one study that has attempted to characterize the disability process in centenarians through a retrospective analysis of late-life functional abilities. This study found high levels of functionality for centenarians until their mid-90s and concluded that centenarians are "living examples of successful aging."⁶ Whether or not this finding makes centenarians representatives of lifelong healthy aging is arguable. In fact, some researchers claim that no truly "healthy" centenarians exist and that a much larger percentage suffer from profound functional limitations if the samples are indeed representative and not skewed toward healthier subjects.⁴

This is, as yet, an unresolved question and to date no other study has used similar methodology to retrospectively explore the late life (nonagenarian years) functional experience of centenarians. Nor has any study that we are aware of examined which arenas of disability are most apt to decline as the oldest-old transition into centenarian status. Therefore, we set out to explore these questions in the southern Japanese island prefecture of Okinawa, which records the highest prevalence of centenarians, as well as among the highest reported levels of functional ability among older persons within Japan.⁷ The Japanese are in turn the population that the World Health Organization defines as leading the world in terms of healthy (disability-free) life expectancy.⁸

METHODS

Study Sample and Procedures

The Okinawa Centenarian Study (OCS) is an ongoing population-based study of centenarians and other selected elderly in the Japanese prefecture of Okinawa that began in 1976. Ages are validated through the *koseki*, the Japanese family registration system.

At the baseline examination, a full geriatric assessment is performed, including physical examination and ADLs. Since the onset of the OCS, limited information on the demographics of the entire centenarian population of Okinawa has been collected and full assessments of a subsample of 900-plus centenarians have been performed.

Study Measurements

Study Subjects. Okinawa prefecture is one of 47 Japanese prefectures and consists of 41 cities, towns, and villages with a total population of approximately 1.3 million. In 2003, 569 centenarians were identified from their family registration records throughout the prefecture. From this larger population, a sample of one city and one village was randomly chosen. The total population of these two municipalities was approximately 123,000. Thus, the study area chosen for this study was home to a subset of the larger population of centenarians within the prefecture representing approximately 8% of the total centenarian population.

Every household where a centenarian was living within these two population centers was then identified (names, dates of birth, and addresses) through their resident registration records (*jumin daicho*) yielding a total of 45 centenarians and indicating complete catchment per the national centenarian list. Each centenarian household was then sent a letter of explanation outlining the study and a request to participate. The study protocol was approved by Okinawa Prefectural University College of Nursing ethics committee.

Data Collection. Data collection was conducted over the period of August to November 2003. After initial mailing of questionnaires centenarian subjects were followed up with a home visit. Of the 45 centenarians identified, five died before data could be collected and 18 refused to participate. Reasons cited for refusal to participate can be divided into two main categories based either on "family circumstances," which included 10 participants (56% of refusals), or "health reasons," which accounted for eight participants (44% of refusals).

Current ADL status of centenarians was assessed by trained interviewers and informants (centenarians, their family members, and caregivers), nursing home records and medical records were consulted to obtain retrospective information on past functional status. Data were collected for time points 0, 1, 3, 5, and 10 years prior and included major medical diagnoses, ADLs, and life situation, among other data. Approximately half the sample had been visited on one or more previous occasions by the same team of investigators over the previous 10-year period.

ADL Instrument: Inoue Index. The Inoue Index is an expanded Barthel Index in common use in Japan.

It defines five levels of functionality: completely independent, independent but slow, independent with difficulty, partially dependent, and completely dependent. Individual items are designed to measure levels of independence for seven physical functions, two sensory functions, and two cognitive functions.

Physical functions include: ability to feed oneself, bowel and bladder continence, ability to stand, ability to bathe oneself, range of mobility within home and neighborhood, and ability to dress oneself. Sensory functions include: auditory acuity and eyesight. Cognitive functions include: ability to express will (self-expression) and ability to respond when spoken to (comprehension of conversation). Each item is scored from 1 (completely dependent) to 5 (completely independent) for a total possible score of 55. In order to be defined as "independent," the centenarian had to score 3 or more on every item and 4 or more on seven of the 11 items.

Statistical Analysis. Mean age was used to represent anchor times for previous assessments. Average score on the various indices was used to judge "deterioration" of functional abilities. Due to small sample size, no statistical analysis was performed and all statements regarding comparisons between items are purely descriptive.

two male centenarians participating in the study were the only two male centenarians living in the study area. The mean age of subjects was 102 years (SD 2.1) with a range of 100 to 107 years. Most subjects were institutionalized (64%), whereas a minority lived in the community (34%). Past medical history included musculoskeletal problems (64%), cardiovascular disease (59%), stroke (41%), cataracts (36%), respiratory ailments (18%), and dementia (9%).

Inoue Index scores were used as proxies for functional independence. Ten years prior, at a mean age of 92 years, 82% (18 persons) of centenarians were functioning independently according to their scores on the Inoue Index. Five years prior, at a mean age of 97 years, 64% (14 persons) were independent. Three years prior, 41% (nine persons) were independent. One year prior, 32% (seven persons) were independent and at the time of data collection 22% (six persons) were still independent.

Adequacy of Performance in Individual Activities of Daily Living

Ten years prior to baseline exam, at an average age of 92 years, all study subjects were able to perform all 11 individual activities of daily living at the level of 4 (independent but slow) or 5 (completely independent) (Table 1). The ability to feed oneself was the most easily performed activity (average score of 5.0) with all subjects able to carry out this item completely independently. Range of movement was the most difficult activity (average score 4.1, SD 1.1) with

RESULTS

Functional Independence

The sample consisted of 22 centenarians of which there were 20 females (91%) and two males (9%). The

TABLE 1. ADL Scores of Centenarians (N=22)

Mean Age	92 Years	97 Years	99 Years	101 Years	102 Years
Years prior to present exam	10	5	3	1	Present
Feeding	5.0 ± 0.0	4.8 ± 0.7	4.8 ± 0.9	4.5 ± 1.4	4.3 ± 1.5
Bowel	4.4 ± 1.3	4.0 ± 1.4	3.3 ± 1.8	2.9 ± 1.9	2.9 ± 1.9
Urination	4.4 ± 1.3	4.0 ± 1.4	3.3 ± 1.8	2.9 ± 1.9	2.9 ± 1.9
Standing	4.2 ± 1.3	3.6 ± 1.5	3.2 ± 1.7	2.8 ± 1.7	2.8 ± 1.7
Movement	4.1 ± 1.1	3.3 ± 1.1	2.9 ± 1.3	2.5 ± 1.3	2.5 ± 1.3
Bathing	4.2 ± 1.2	3.7 ± 1.2	3.4 ± 1.4	2.8 ± 1.3	2.8 ± 1.3
Dressing	4.2 ± 1.3	3.8 ± 1.3	3.2 ± 1.4	2.7 ± 1.5	2.7 ± 1.5
Hearing	4.4 ± 1.1	4.0 ± 1.1	3.7 ± 1.2	3.5 ± 1.4	3.4 ± 1.4
Sight	4.7 ± 0.6	4.5 ± 0.8	4.4 ± 0.8	4.1 ± 1.1	4.1 ± 1.1
Expression	4.8 ± 0.6	4.6 ± 1.0	4.4 ± 1.2	4.0 ± 1.5	4.0 ± 1.5
Awareness	4.8 ± 0.6	4.5 ± 1.0	4.3 ± 1.1	4.1 ± 1.3	4.1 ± 1.3
Total ADL score	49.0 ± 8.1	45.0 ± 9.3	40.8 ± 11.5	36.8 ± 12.5	36.6 ± 12.6

Notes: Data are mean ADL scores ± standard deviation. A perfect score is 5 points per item and 55 overall. Score for each item is average of all participants.

centenarians being independent but slow on average. Five years later, at age 97 years, four activities—range of movement, standing, bathing, and dressing—had become challenging to perform, although subjects still reported being able to independently perform these activities, but with difficulty. At age 99 years, subjects' range of movement had further deteriorated to the point where most had crossed the threshold from independent into partial dependency (average score of 2.9 ± 1.3) and independence in the activities of "hearing" and "continence" were becoming difficult. At age 101 years, one year prior to measurement, centenarians had become partially dependent in the activities of continence, standing, range of movement, bathing, and dressing. Interestingly, there was little change from one year prior to time zero, although one more centenarian had passed from independence to dependence. Cognitive abilities such as expression of will and comprehension of conversation were retained at a level of independent but slow throughout the previous 10 years.

DISCUSSION

The oldest old (including centenarians) are the fastest growing segment of the population of the United States and many other developed countries. As more members of the population reach what was once considered an exceptional age, it has become vitally important to know if it is possible to attain this milestone and still be functionally independent. This not only reflects potential quality of life for our elders but has significant economic consequences because the oldest old are the largest consumers of health resources.

Following an earlier retrospective analysis in the United States that found high numbers of centenarians functioning independently up until near the end of their lives,⁶ this study set out to answer a similar question in a nonwestern setting. It was encouraging to find that the centenarian subjects from this study also remained functionally independent for most of their exceptionally long lives.

These results support surveys of long-term care utilization throughout Japan (a proxy measure of disability-free life expectancy) that show Okinawan seniors to be among the highest functioning older

populations within Japan.⁷ Because Japan has the world's longest healthy life expectancy,⁸ these findings are suggestive that Okinawa's oldest old may be experiencing a delayed aging process or at least a postponement of disability.

Compared with the older population in general, centenarians seem to delay or avoid many of the diseases that claim the lives of their contemporaries⁹ and most studies estimate 10% to 20% may be considered functionally independent.¹⁻⁶

The current finding that Okinawan centenarians seem to remain functionally independent throughout their 90s, likely by delaying or avoiding deadly diseases until late in life, does not necessarily mean that they should be considered "healthy." This interpretation is supported by the Danish Centenarian Study which showed that only one of over 200 centenarian subjects examined turned out to be "free of disease."³

Differences in measurement and assessment techniques that include disease definitions, the diseases included in profiling the subjects, as well as whether a study uses self-report measures, clinical examination, or performance-based functional measures, are likely responsible for at least some of the different findings among different study populations. For example, the aforementioned U.S. study⁶ excluded osteoarthritis due to its near ubiquity among the very old, whereas the Danish study³ did not. This methodological difference effectively disqualified most Danish centenarians from the possibility of being defined as disease-free, while allowing the U.S. study to define 19% of subjects as without significant illness.

Although the findings from this study were similar to the previously mentioned retrospective analysis of centenarians in the United States,⁶ the present study cannot be directly compared to the U.S. study because differences exist in measurement instruments and techniques as well as definitions of what constitutes functional independence.

The present study included a larger number of items that included physical, sensory, and cognitive functions and a wider range of possible levels of functioning in order to get a better understanding of the disability process and which aspects of function were observed to be the most resilient.

Of note, this study measured three domains of function including physical, sensory (eyesight and hearing), and cognitive (expression of will and understanding of conversation). The inclusion of these

latter domains would lower overall scores because poor hearing and failing eyesight (especially cataracts) are highly prevalent among the elderly. Interestingly, range of movement was the first ADL function to begin to decline for most centenarians and self-feeding was maintained the longest. This is in accordance with studies of the disability process and life space of younger elderly in at least one other population.¹⁰

Strengths of this study include sampling methodology. Every household where a centenarian was living within these two population centers was identified providing a subset of approximately 8% of all centenarians in Okinawa. Moreover, refusals were not based solely on factors that differentiated healthy from unhealthy centenarians with the majority (56%) based on family circumstances.

Limitations of the study include the small numbers of subjects recruited. Furthermore, we cannot fully discount the possibility that certain selection factors were operating. For example, dementia rates appear low in the sample we studied. Eight participants (44% of refusals) declined to participate because of health reasons. Although only three of the potential participant's families mentioned dementia as the specific health reason, likely there were more potential participants with significant cognitive impairment who were eliminated from the study due to refusals.

Finally, the comparability of the study is also somewhat limited due to the different tools and definitions used to measure functional independence. Nevertheless, these data are unique and important because they illustrate the late-life functional experi-

ence of a population that has among the highest functional status in the world.

Living longer increases the heterogeneity of disease among the elderly and very old individuals are continually confronting the challenges that result from having to cope with numerous physical and social losses. Moreover, older people adapt to physical and social losses in various ways depending upon their functional reserve, other impinging comorbidities, and coping strategies. With this in mind, disability is best conceived of as an interactive process. That is, as a dynamic interaction between health conditions and contextual factors. Mediating factors include support resources, such as an adequate social support network, financial resources, and personal competencies such as attitudes, skills, or coping abilities needed to deal with declines in health.

The extent to which these factors and favorable genetics support the high functional status of Okinawa's older population merits further study. Discovering the genetic and environmental factors that lead to high functional status and resistance to the diseases of aging could have enormous potential consequences for human health.

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