

Fig. 1 Progress of the NILS-LSA

3) Objectives of the NLS-LSA

1. Main purpose

Systematic observation and description of the process of normal aging in humans.

- (1) To quantify normal and successful aging
- (2) To determine the reference values in normal aging process by longitudinal observation

2. Additional purpose

- (1) To find out early markers of age-related diseases
- (2) To clarify molecular genetic factors of aging and geriatric diseases
- (3) To find out factors associated with longevity
- (4) To examine the effects of life-style, stress, life events and disease on aging process
- (5) To separate normal aging and age-related disease
- (6) To assess the influence of age on progressive changes of various diseases
- (7) To determine predictors of age at death and risk factors for diseases as well as institutionalization and loss of independence
- (8) To examine race difference by international comparative study
- (9) To assess social and economical changes with age in the elderly
- (10) To develop indices of biological age
- (11) To prepare basic population for the research of clinical and social medicine

4) Research area

The NILS-LSA is a facility-based study using various equipments including MRI, DXA and pQCT for the detailed and comprehensive assessments of aging and geriatric disease. The facility of examinations is located at the NILS. Thus, the research area was determined to be in the neighborhood of the NILS, that is Obu city (population 79,000) and Higashiura town (population 48,000) (Fig. 1). This area is located in the south of Nagoya, and is a bedroom town and also industrial area of the Toyota group, but still has many orchards and farms, having both urban and rural characteristics.

This research area is geographically located at the center of Japan, and the climate is almost Japanese average. We examined the representativeness of the area via national postal questionnaire of prefecture-stratified random samples of 3,000 households from all prefectures in Japan, and found that the life-style of this area was the most typical of all areas in Japan. It is expected that the results of examinations in this area will represent Japan.

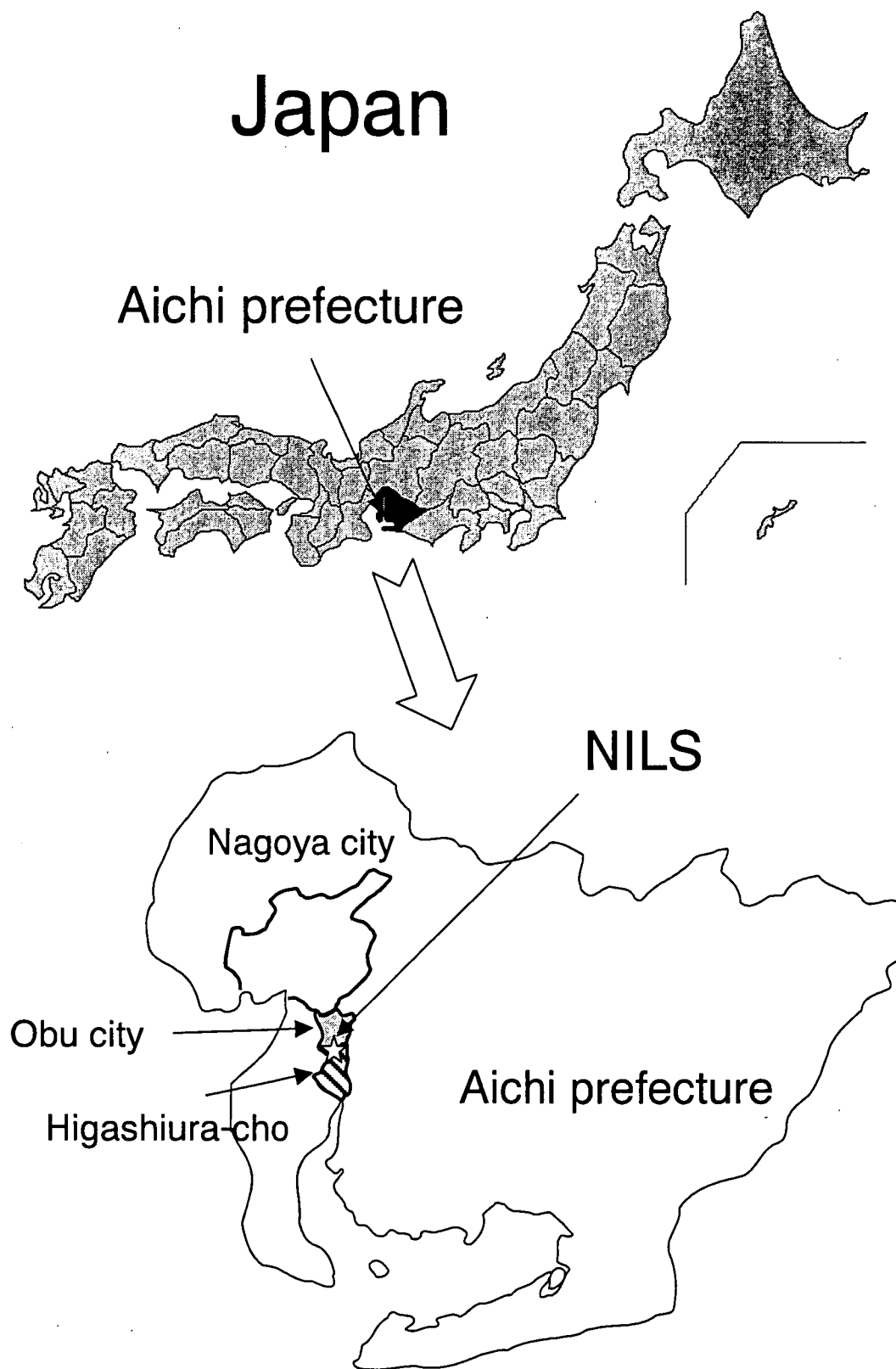


Fig. 2 Research area of the Nils-LSA

5) Subjects

The subjects of baseline examination of the NLS-LSA were males and females aged 40 to 79 years old. The population of Obu city and Higashiura town was stratified by both age and gender, and randomly selected from resident registrations in cooperation with the local governments (Fig.3). The number of males and females was to be equal to test gender difference, and the number of participants in each decade (40s, 50s, 60s, 70s) was also to be equal. The total number of participants was to be 2,400, that is 300 males and 300 females for each decade. They will be followed up every two years. Age and gender-matched random samples of the same number of dropout participants will be recruited except the participants over 79 years old. The male and female participants aged 40 years will be also newly recruited every year (Fig.4). Table 1 shows age and gender distribution of the participants in the first wave examination. Table 2, Table 3, and Table 4 also show age and gender distribution of the second, third, and fourth wave participants, respectively. About two third (65.8%) of the first wave subjects were participated in the fourth wave examination (Table 5), and 89.2% of the third wave participants came back for the fourth wave examination (Table 6).

Recruitment and follow up of volunteers would be much easier than with random samples. However, these samples generally tend to be interested in health, and observation of these samples would produce biased results. Examinations in random samples are necessary to observe the aging process of ordinary Japanese who live ordinary lives.

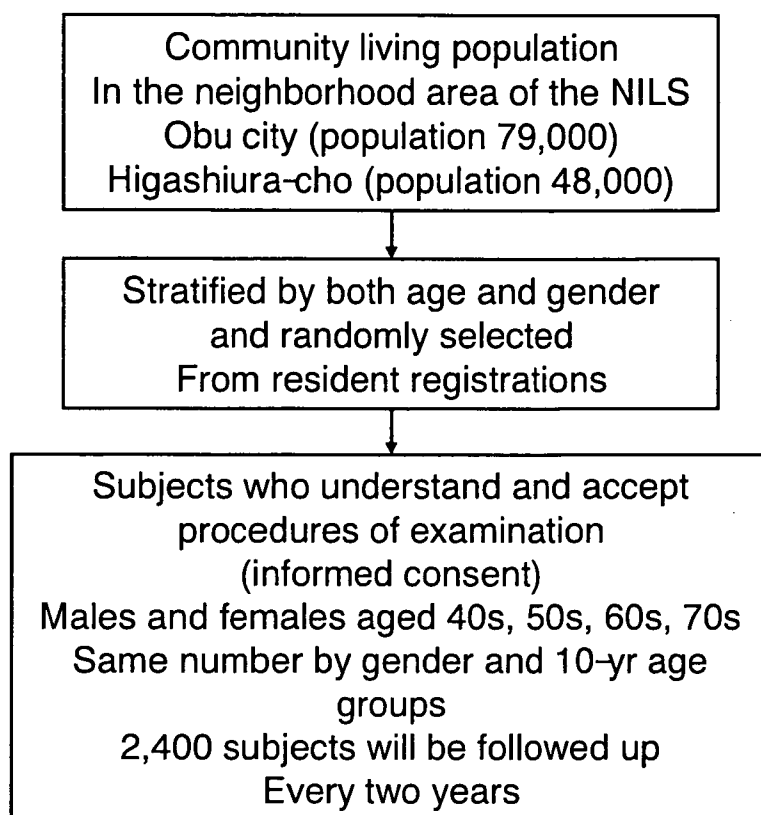


Fig. 3 Selection of the subjects in the NLS-LSA.

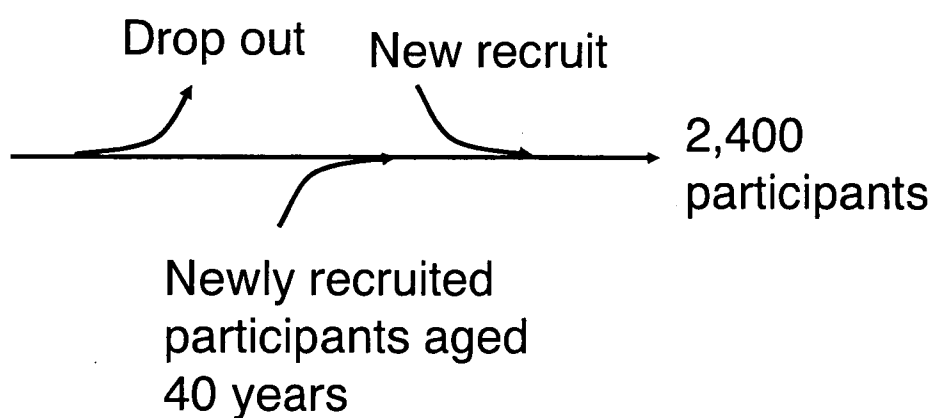


Fig. 4 NLS-LSA as a dynamic cohort

Table 1. Age and gender distribution of the first wave participants

Age	Male	Female	Total
40 – 49	291	282	573
50 – 59	282	279	561
60 – 69	283	285	568
70 – 79	283	282	565
Total	1,139	1,128	2,267

Table 2. Age and gender distribution of the second wave participants

Age	Male	Female	Total
40 – 49	273	261	534
50 – 59	296	284	580
60 – 69	291	271	562
70 – 79	275	269	544
80 –	17	22	39
Total	1,152	1,107	2,259

Table 3. Age and gender distribution of the third wave participants

Age	Male	Female	Total
40 – 49	266	294	560
50 – 59	331	285	616
60 – 69	297	286	583
70 – 79	267	275	542
80 –	43	34	77
Total	1,204	1,174	2,378

Table 4. Age and gender distribution of the fourth wave participants

Age	Male	Female	Total
40 – 49	286	294	580
50 – 59	295	283	578
60 – 69	300	273	573
70 – 79	255	285	540
80 –	53	59	112
Total	1,189	1,194	2,383

Table 5. Number of males and females who participated both the first and fourth wave examinations

	Male	Female	Total
First wave	1,139	1,128	2,267
First and fourth wave	766	726	1,492
Percentage	67.3%	64.4%	65.8%

Table 6. Number of males and females who participated both the third and fourth wave examinations

	Male	Female	Total
Third wave	1,204	1,174	2,378
Third and fourth wave	1,018	997	2,015
Percentage	84.6%	84.9%	84.7%

6) Implementation of the study

Randomly selected males and females who were assigned to the examination were invited by mail to an explanatory meeting that was held (Fig. 5). At the explanatory meeting, procedures for each examination and the importance of continuation to follow up were fully explained. Participants were limited to those who accept examination procedures and sign their names on a written form (informed consent).

The Department of Epidemiology of the NILS was taking the initiative for all examinations and investigations. The participants were examined from 9:00 am to 4 pm at a special examination center within a facility at the the NILS. To examine 2,400 males and females in two years, that is, 1,200 males and females per year, six or seven participants were to be examined each day, four days a week from Tuesday to Friday, 200 days (50 weeks) a year. Taking advantage of the fact that all participants can be examined at the center, detailed examinations including not only medical evaluations, but also examinations of exercise physiology, body composition, nutrition, and psychology can be done. Each examination was to be extensive and most up-to-date, aiming at keeping the internationally highest level. The follow up period is to be up to 30 to 50 years.

Information from the examinations that would be helpful to manage the health was returned to individual participants as a report from the NILS-LSA.

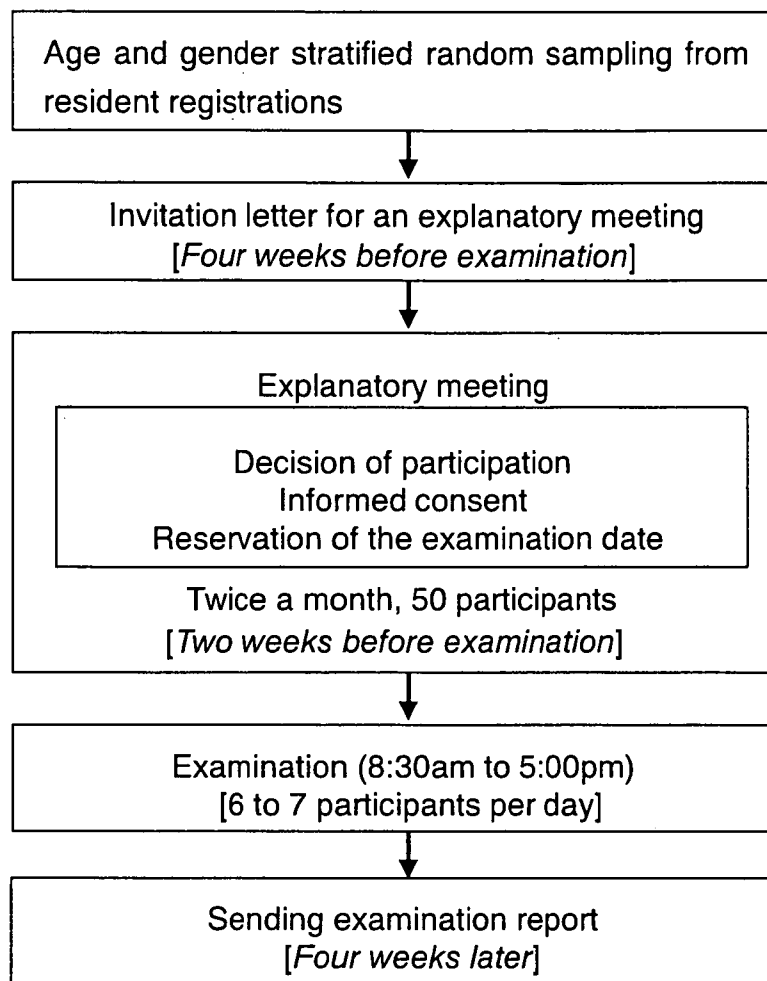


Fig. 5 Examination schedule in the NILS-LSA.

7) Informed consent

Participation in the examinations totally depended on free will, without any enforcement. All participants were fully informed of the following items. Only subjects who understood and accepted examination procedures, and signed their names on a written form to participate in the study (informed consent) were included. This informed consent included; (1) purpose of the study; (2) detailed procedures for each examination; (3) gene analysis; (4) preservation of blood, urine and DNA samples for future examinations; (5) to send examination report to the participants; (6) to keep personal data secret. The Ethical Committee of the National Center for Geriatrics and Gerontology had already approved all procedures of the NLS-LSA.

8) Examinations and tests

The normal aging process was assessed by detailed examinations including clinical evaluation, sensory functions, body composition and anthropometry, physical functions, nutritional analysis, and psychological tests (Table 7).

The NILS-LSA is a longitudinal study to observe age related changes of various examination and tests. Thus examinations and tests of the fourth wave were basically same with the third examination.

Table 7. The fourth wave examinations and tests in the NILS-LSA

Health related questionnaire

Self-rated Health (SRH), Medical history, Clinical symptoms, Family history, Environment, Smoking

Routine clinical evaluations

Physical examination

Blood pressure

Blood chemistry (fasting)

GOT, GPT, gamma-GTP, Total protein, Albumin, LDH, Alkaline phosphates, Choline esterase, Uric acid, Creatinine, Calcium, Phosphate, Total cholesterol, Triglyceride, HDL-cholesterol, Lipid peroxide, Fasting glucose, HbA1c, Insulin, Serum sialic acid, Fe.

CBC: Red cell count, White cell count, Hb, Hematocrit, Platelet count

Sensory examinations

Visual system

Visual acuity: Presenting Visual Acuity, Best-corrected Visual Acuity (5 m), Refraction, Retinal fundus camera, Intraocular pressure, Stereoscopic vision, Contrast sensitivity, Corneal thickness, Retina tomography

Auditory system

Audiometry (air and bone), Middle ear functions (Single frequency and Multifrequency tympanometry), Distortion product otoacoustic emission (DPOAE), Video recording of tympanic membrane

Medical examinations

ECG (Automatic ECG analyzer)

Cardiac ultrasonic tomography

Intima-media thickness of carotid artery

Head MRI (Magnetic resonance imaging system)

Thoracic and lumbar radiography

Dual energy X-ray Absorptiometry (DXA)

Lumbar spine, Right and left femur neck, Total bone density, Body fat (total and segmental fat)

Oral examinations

Dental caries

Periodontal index

Denture use

Tongue coat

Tongue wetness

Bite force

Anthropometry and body composition

Anthropometric measurements

Body fat measurement

Dual energy x-ray absorptiometry (DXA)

Body fluid measurement (Bioimpedance spectroscopy)

Intra- and Extra-cellular fluid

Thickness of fat and muscle tissue (Ultrasonic tomography)

Intra-abdominal fat, Muscle thickness, Subcutaneous fat thickness

Abdominal fat distribution (Computed tomography)

Intra-abdominal and Subcutaneous fat area

Physical function

Exercise test system

Grip strength, Sit-up, Trunk flexion, Static balance, Leg extension power, Isometric knee extension strength, Reaction time, Maximum step length.

10m walking test (pitch, step length, velocity),

3-D motion analysis system (four cameras and two force plates)

Stabilometer (with or without eye closed conditions)

Physical activity questionnaire

Electric pedmeter (7 days average)

Psychological tests

Interview

Cognition (MMSE, WAIS-R), Life events, Stress, Social relations, Basic ADL (Katz Index)

Questionnaire

Depression (CES-D, GDS), Personality (Rosenberg Self-Esteem Scale, Locus of control, Scale of Attitude toward Death), Social relations, Subjective well-being (LSI-K), Stress checklist, Stress coping scale, Instrumental ADL, Life-style, Personal history (job, marriage, education, etc.), Social and economical back ground

Nutrition analysis

Food and nutrition intake

Three-day dietary record using scale and disposable camera

Dietary supplement frequency interview

Beverage frequency questionnaire

1. Routine clinical evaluations

First of all, physical examinations including history taking, auscultation and blood pressure were taken by a physician, and during the medical examination the physician reconfirms every participant willingness to participate in examinations. Venous blood and urine samples were collected early in the morning after at least 12 hours' fasting.

Life-style, personal history (job, marriage, education, etc.), family history, environment, smoking, social and economical back ground, health status, clinical symptoms, medical history and medication were examined by questionnaires. These questionnaires are checked by a physician at the medical examination. All drugs were to be documented by participants; the physician confirms them by interview and codes drugs used during the last two weeks.

Blood and urine analysis including renal and liver functions, serum protein and lipids, minerals, glucose, HbA1c, Insulin, sialic acid, , and complete blood count were also examined. DNA of the first visit participants was stored in deep freezers for future examinations.

2. Physiological examinations

For physiological examinations, a head MRI was taken for the each participant and stored in an image database. Intracranial tumors and vascular lesions are checked and brain atrophy was assessed via a computerized trace of the MRI. Electrocardiograms are assessed by computerized automatic diagnosis and Minnesota codes of the diagnosis were stored in a database. Cardiac functions and intima-media thickness of the carotid artery were assessed by ultrasonic tomography. Blood pressure was measured by a physician as well as with an automatic blood pressure manometer.

Osteoporosis is one of the major geriatric diseases. Osteoporosis causes chronic lumbago and bone fracture that disturbs activity in daily life in the elderly. Bone mineral density was measured by dual x-ray absorptiometry (DXA, Hologic QDR-4500). Four scans, including whole body, lumbar spine L2 to L4, right and left femoral bone neck, were taken.

3. Sensory examinations

Sensory functions are profoundly associated with QOL in the elderly. Visual and auditory disturbance causes various difficulties in the daily lives of the elderly. Sensory functions, including visual and auditory functions were examined in detail.

Distant visual acuity was measured for each eye with a Landolt C letter at 5m. Contrast sensitivity and intraocular pressure were also examined. Fundus photographs were taken with a Topcon fundus camera (TRC-NW5S). Autorefraction was done with the NIDEK-ARK700A. Refractive errors, in the spherical equivalent, were assessed. Corneal thickness was obtained with the Topcon SP-2000 specular microscope.

Auditory function assessed by pure-tone audiometry (Audiometer RION AA-73A), and impedance audiometry (Middle Ear Analyzer, Grason-Stadler model 33, version 2). Air conduction thresholds at 125Hz to 8000Hz were examined in all participants. Bone conduction thresholds at 250Hz to 4000Hz were examined in participants with elevation of air conduction thresholds. Middle ear function was evaluated by impedance audiometry. Inner ear function was also assessed by distortion product otoacoustic emission (DPOAE).

4. Oral examinations

Caries, periodontal index, and tongue coat were evaluated by a well trained dentist with a dental mirror and WHO CPI probe. All teeth were classified into intact, decayed, filled, missing, or caries observation. Periodontal index (CPI score) on 10 index teeth (17/16, 11, 26/27, 36/37, 31, 46/47) were derived according to World Health Organization standard. Score of tongue coat was given by its area on the tongue dorsum. Denture use was asked by a dentist on verbal. Score of tongue wetness was determined by putting Elsalibo R on the tongue dorsum for 10 seconds. For the assessment of bite force, each subject clenched a pressure sensitive sheet (Dental Prescale R 50H, GC Co. Ltd.) as hard as they could at the intercuspal position for 3 seconds. Average bite force were determined by an image analyzer (Occlusizer R FPD703, GC Co. Ltd.).

5. Anthropometry and body composition

For anthropometry measurements, height, weight, abdominal sagittal diameter, circumferences of waist, hip, thigh and upper arm and other parameters were taken. Using ultrasonic tomography, intrabdominal and subcutaneous fat thickness and muscle thickness were evaluated. Intra- and extra-cellular fluid was measured via bioimpedance spectroscopy. Body fat was assessed by DXA. Abdominal fat distribution was evaluated as intra-abdominal and subcutaneous fat areas at the level of umbilicus using a computed tomography

6. Exercise examinations

Grip strength, leg extension power, sit-up and static balance, reaction time, and trunk flexion were measured with a computerized automatic diagnosis system. Step length, pitch, and velocity of walking were assessed by the 10m walking test using four video cameras and two force plates. Physical activities were checked by detailed interview using job-specific questionnaire sheets. Seven-day averages of physical activity were also measured with an electric pedometer.

7. Nutritional survey

Nutritional intakes were assessed by three-day dietary record using a scale. The scale was handed out to each participant to record the weight of each food taken over the recording period. If it was impossible to weigh each food, approximate size and amounts of food were noted. Dieticians explained to each participant how to weigh foods and how to determine the size and approximate amount. For more accurate assessment, disposable cameras were also handed out to all participants. Before and after each meal, participants were asked to take pictures of all dishes to record what kind of foods and how much food were eaten, and how much food was not eaten. Using these dietary records and photographs, dieticians estimate actual food intake. Dietary supplement usage was also assessed by interview by dietitians in addition to three-day dietary record.

8. Psychological test

All participants were interviewed by psychology specialists. Cognition and intelligence were assessed using the Wechsler Adult Intelligence Scale-Revised Short Form (WAIS-R-SF) in all participants and the Mini-Mental State Examination (MMSE) in participants aged 60 years and over. Life events, hassles, and stress coping were also assessed by interview. Basic ADL was checked via the Katz index.

Depressive symptoms, personality, subjective well-being, social relations, and ADL were assessed using a questionnaire.

Over 1,000 variables, including various areas of gerontology and geriatrics will be checked repeatedly every two years in almost 2,400 participants. The staff of the NILS-LSA were consisted of full time researchers, researchers from hospitals and universities, research assistants such as administrators, clinical technicians, dieticians, psychologists, and radiologists. The total number of staff was about 90.

9) Future of the NLS-LSA

We will continue the NLS-LSA to investigate the natural course of aging and the changes that lead to disease. The fourth wave examination was completed in July 2006. The participants will be examined every 2 years. The cohort of the NLS-LSA is a dynamic cohort, that is, new subjects participate in the study instead of those who do not attend their next examination. Participants who move out of the area are to be followed up by telephone interview or postal questionnaire. Medical records of the participants who die during follow-up will be checked to find out the cause of death.

Extensive tests and examinations should be repeated in longitudinal studies on aging. However, it is actually impossible to repeat many tests and examinations in multiple research facilities with the same protocols and methods. Thus, there are almost no comprehensive longitudinal studies on aging that have been followed up for a long period by multi-center collaboration in the U.S. or other countries.

However, cohort studies with common end points such as dementia and disturbance of ADL are also important for aging studies. For these studies, a relatively large number of subjects and cases during follow-up will be required to get significant analysis results. We are collaborating with other research facilities in Japan and other countries as shown in Fig. 6.

Comparative studies of the aging process accounting for regional and cultural differences between northern and southern areas, or between urban and rural areas, are also important. In these comparative studies, the number of common examinations and tests should be limited. The study design should be a cross-sectional or short-term longitudinal study, considering the difficulties involved continuing and repeating the examinations in all facilities with same protocols.

We are going to make the data of this study public through the Internet. We hope that the results from this large longitudinal study of aging can serve the development of health science on aging.

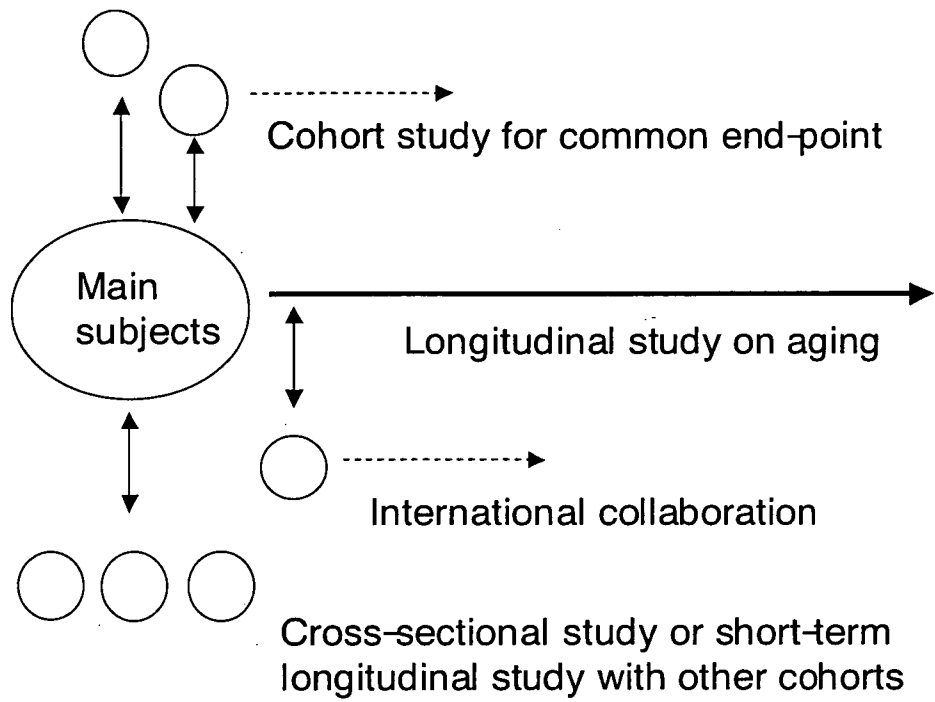


Fig. 6 Design of the longitudinal study by multi-center collaboration

10) Staff of the fourth wave examinations

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