Published in final edited form as:
Dement Geriatr Cogn Disord. 2008 ; 26(2): 153–160. doi:10.1159/000149819.

Cohort Changes in Cognitive Function among Danish Centenarians:

A Comparative Study of 2 Birth Cohorts Born in 1895 and 1905

Henriette Engberg, **Kaare Christensen**, **Karen Andersen-Ranberg**, and **Bernard Jeune**
Danish Aging Research Center, Epidemiology Unit, Institute of Public Health, University of Southern Denmark, Odense, Denmark

Abstract

Background/Aim—The objective was to examine cohort changes in cognitive function in 2 cohorts of centenarians born 10 years apart.

Methods—The Longitudinal Study of Danish Centenarians comprises all Danes reaching the age of 100 in the period April 1, 1995 through May 31, 1996. A total of 207 out of 276 persons participated (75%). The Danish 1905 Cohort Survey includes all individuals born in 1905. In total, 225 out of 364 persons who reached the age of 100 in the cohort participated in the most recent 2005 follow-up (62%). In both cohorts, cognitive function was assessed using the Mini-Mental State Examination.

Results—There were no significant differences in cognitive score between the two centenarian birth cohorts. However, modest tendencies were seen towards better cognitive functioning for the centenarians in the 1905 cohort living at home compared to the home-dwelling ones in the 1895 cohort and worse cognitive performance for the centenarians in the 1905 group living in nursing homes compared to the nursing home dwellers in the 1895 cohort.

Conclusion—The increasing number of centenarians may not entail larger proportions of cognitively impaired individuals in this extreme age group.

Keywords

Cognition; Centenarians, Danish; Cohort effect

Introduction

The oldest-old, including nonagenarians and centenarians, are the fastest growing segment of the population in western developed countries. On average, the number of people reaching the age of 100 doubles every 10 years in low-mortality countries [1]. This has led to an ongoing debate about whether increases in exceptional longevity mean healthier oldest-old populations or not [2,3]. Becoming a centenarian is not desirable if good cognitive and physical abilities are not retained. Centenarian studies are not only relevant to future generations of oldest-old but also important as a guide in the provision of care for an aging population.

Only few countries can fuel the debates on how the very long life ends with empirical data, and even fewer are able to compare birth cohorts of centenarians. In Denmark, one of the first

Henriette Engberg, MSc (Health) The Danish Aging Research Center Institute of Public Health, University of Southern Denmark J.B. Winsløwsvej 9B, DK-5000 Odense C (Denmark) Tel. +45 6550 3380, Fax +45 6550 3682, E-Mail hengberg@health.sdu.dk.

centenarian surveys was conducted in 1995 and repeated again in a 10-year-younger birth cohort in 2005 [4]. This unique data material offers the possibility of examining cohort differences in health and function among centenarians. The present study focuses on the cognitive aspect.

Age-related loss of cognitive abilities has been established in several mainly cross-sectional trials [5-8]. The only study at present examining trends in cognitive function among centenarians showed a decline in cognitive abilities among cohorts of Okinawan centenarians from the 1970s to the 1990s. Cognitive performance declined more among community-dwelling centenarians than among those living in institutions [9].

In the present investigation, we compared cognitive function as assessed using the Mini-Mental State Examination (MMSE) in 2 birth cohorts of centenarians born 10 years apart in Denmark. The MMSE has been employed in several other centenarian studies, despite the problems of vision and hearing impairment in this extreme age group [10-14], and represents a commonly accepted psychometric test in the research of cognition and dementia [5].

With about 42% more of the 1905 cohort making it to 100 years compared to the 1895 group, we tested whether the younger cohort would display worse cognitive performance than the older one. The study also focused on differential trends according to sex and housing.

Methods

Study Population

The study was based on a comparison of 2 Danish centenarian cohorts born in 1895/1896 and 1905.

The Longitudinal Study of Danish Centenarians (LSDC) comprises all individuals celebrating their 100th birthday in the period April 1, 1995 through May 31, 1996. The names and addresses of all eligible individuals were identified through the Danish Civil Registration System. A total of 207 out of 276 eligible 100-year-olds participated in the survey (75%). A non-response analysis showed no significant differences between responders and non-responders regarding gender, housing and mean number of hospitalizations in the previous 18 years [15]. The personal interview consisted of sociodemographic variables and health, and cognitive testing using the MMSE as well as a clinical examination [16,17]. The scientific ethics committee of the counties of Funen and Vejle, Odense, Denmark, approved the study (trial numbers: 95/93 and 95/93MC). The LSDC is described in detail in Andersen-Ranberg et al. [15].

The Danish 1905 cohort survey comprises all individuals born in 1905 and living in Denmark on April 1, 1968, identified through the Danish Civil Registration System. At baseline in 1998, a total of 3,600 persons were still alive in the cohort, and of these 2,262 (63%) participated in the baseline survey. The baseline survey and subsequent follow-ups consisted of a personal interview in the respondents' home covering sociodemographic factors, medical status, health and cognitive functioning. Cognitive performance was assessed using the MMSE [16]. Trained interviewers from the Danish National Institute of Social Research carried out the survey. Since baseline, in-person follow-up surveys have been conducted every 2-3 years. The most recent one took place in 2005, when the survivors could celebrate their 100th birthday, and a total of 166 respondents participated. To increase the number of participants in the 2005 follow-up, all earlier non-responders from previous waves were re-contacted. This yielded another 90 persons, increasing the total number of respondents in the last wave to 256. Not all of the respondents had reached the age of 100 at the time of the last interview. In this cohort comparison we included only those in the 1905 cohort who lived to celebrate their 100th birthday before death, in total 225 out of 364 eligible respondents (62%). A non-response

analysis showed no difference between participants and non-participants with regard to gender (females, 84 vs. 89%, p = 0.213), median number of hospitalizations (p = 0.56) or bed days in hospital (p = 0.71) during the years 2003 and 2004 (online suppl. table 1, www.karger.com/doi/10.1159/000149819). The 1905 cohort is described in detail elsewhere [18,19]. The ethics com mittee system in Denmark approved the study (trial number VF20040240).

Measures

Housing was divided into a binary variable reflecting whether the respondent was living at home or in a nursing home. The nursing home group also included those living in sheltered housing.

Educational level was dichotomized into 2 categories reflecting whether the respondent had 7 or less or more than 7 years of schooling.

Marital status was a binary variable reflecting whether the participant was married or not. Divorced or separated respondents were assigned to the non-married group.

Cognitive function was assessed using the MMSE developed by Folstein et al. [16]. The MMSE is subdivided into 6 areas of cognitive functioning: orientation, registration, calculation or attention, recall, language and praxis. The correct scores of each area are summed to a maximum score of 30 points. In the present study, the total scores were divided into 3 categories using the conventions established in the Epidemiologic Catchment Area studies in the USA [20]: cognitive impairment was graded as severe for those having scores between 0 and 17, mild for scores between 18 and 23 and not present for scores between 24 and 30.

Because the MMSE relies heavily on visual and auditory abilities, the failure of reaching scores at or above the normality threshold of 24 may be due to visual or hearing impairment, especially at advanced ages [11,21]. To address this, we calculated the MMSE Index, which is a numerical value between 0 and 1 reflecting the ratio between the actual score and the maximum obtainable score in the MMSE, taking into account the existence of visual impairment. This can be done by reducing the maximum obtainable score by scores according to the questions in the MMSE that require vision. Five items in the MMSE concern vision: item 6 (name 2 things in front of you - 2 points), item 8 (a 3-stage command - 3 points), item 9 (read and obey a sentence - 1 point), item 10 (write a sentence making sense to the interviewer - 1 point) and item 11 (copying 2 overlapping pentagrams - 1 point). The total score of these items is 8 points. Thus, the standard maximum score of 30 can be reduced down to 22 points. However, it is possible to reduce the maximum score by less than 8 points if the respondent is able to perform and complete some of the above-mentioned items despite his or her visual impairment. The maximum obtainable score for the visually impaired respondents can therefore vary between 22 and 29 points.

We dealt with missing information due to visual impairment by calculating the MMSE Index for each respondent as described above. The MMSE Index was then divided into 4 groups according to Motta et al. [22], with 1.00-0.81 reflecting no cognitive impairment, 0.80-0.63 indicating slight signs of cognitive injury, 0.62-0.40 reflecting moderate cognitive decline and 0.39-0.00 equal to severe cognitive impairment. The `no cognitive impairment' and the `slight signs of cognitive impairment' groups are considered in the normal range established for the elderly [22]. In addition to the categorization of the MMSE scores and the calculation of the MMSE Index, the median MMSE score in both cohorts was compared. Missing information due to non-response or refusal was scored as error, i.e. the respondent was assigned 0 points for the particular item, following the recommendations by Fillenbaum et al. [23].

Data Analysis

Differences in categorical variables between the cohorts were analyzed using the Fisher Exact test. Comparison of group medians on the MMSE was performed with the Wilcoxon rank sum test. A p value of <0.05 was considered to indicate statistical significance. The data were analyzed using STATA Statistical Software Package version 8.2, Stata Corporation [24].

Results

There was a clear-cut predominance of women compared to men in both cohorts, and over time an increasing trend was evident. In favour of women, the sex ratios equalled 3.6 in the LSDC and 5.3 in the 1905 Cohort Survey. With regard to housing, a slightly higher proportion of the centenarians in the 1905 cohort compared to the 1895 group was still living in their own home. The proportion of women in the 1905 cohort living in nursing homes was significantly lower than in the 1895 group ($p = 0.04$). Overall, the cohorts did not differ significantly with respect to educational level or marital status. Stratified by gender, a significantly higher proportion of males in the 1905 cohort compared to the 1895 one had more than 7 years of schooling ($p = 0.04$), but the numbers were small (table 1).

Approximately 75% of the centenarians in the LSDC and 78% of those in the 1905 Cohort Survey were tested using the MMSE (table 2). The observed differences in the MMSE scores were not statistically significant. However, the prevalence of no cognitive impairment was slightly higher in the 1905 cohort than in the 1895 group due to a higher proportion of men in the 1905 cohort having scores reflecting no cognitive impairment (54 vs. 33%). No cohort differences were seen with respect to the MMSE Index. However, the proportion of men without cognitive impairment was higher in the 1905 than in the 1895 cohort (43 vs. 28%), although non-significant due to the small number of males.

Table 3 depicts the distribution of MMSE scores stratified by housing and sex. The majority of the observed differences were small and not statistically significant. The home-dwelling centenarians in the 1905 cohort had better cognitive function than those living at home in the 1895 cohort. Stratified by gender, this was due to a higher proportion of men in the 1905 cohort having scores reflecting no cognitive impairment (77 vs. 21%), but the numbers were small. Among the centenarians living in nursing homes the opposite tendency was evident in both sexes. The participants living in nursing homes in the 1905 cohort were more cognitively impaired than the nursing home dwellers in the 1895 group (50 vs. 41%), especially among women.

In a previous paper we had found an increased use of common assistive devices such as a walker, an elevated toilet seat, a bathing chair and handles or a handgrip in the 1905 compared to the 1895 cohort [4]. This increased use of assistive devices was observed both among home-dwelling centenarians and individuals living in nursing homes. In the present study we found that among the home-dwelling centenarians there was a tendency towards worse cognitive function for the participants using assistive devices but better cognitive performance for the centenarians not employing such tools in the 1905 cohort compared to the 1895 group. For the centenarians living in nursing homes a tendency towards worse cognitive function was present in the 1905 cohort independently of the use of assistive devices (data not shown).

The proportion of centenarians who could perform a complete or an incomplete MMSE was approximately the same in both cohorts (table 4). Comparing the samples within the groups of complete or incomplete MMSE did not reveal any systematic differences in MMSE scores. However, the proportion of subjects in the 1905 cohort with a complete MMSE and a high MMSE score was a little higher than in the 1895 one. Among the centenarians who could not perform a complete MMSE, visual impairment was the most frequent reason in both cohorts.

Discussion

Overall there were no systematic differences between the cohorts with respect to cognitive function as measured using the MMSE. Among the centenarians living at home and those living in nursing homes, modest tendencies were seen towards both better and worse cognitive performance in the 1905 compared to the 1895 cohort: in the 1905 sample the men living at home had better cognitive performance than those in the 1895 group, but the numbers were small. Comparing the nursing home dwellers of the 1905 cohort with those of the 1895 sample, there was a tendency towards more cognitive impairment, especially among women.

A slightly higher proportion of centenarians was living in their own home in the 1905 cohort compared to the 1895 one. This could be a reflection of increased allocation of resources to home health care services. In a previous paper we had found an increased use of common assistive devices in the 1905 cohort compared to the 1895 cohort [4], both among centenarians living at home and among nursing home dwellers. The additional analysis in the present study may indicate that this increased use of assistive devices allows a higher proportion of centenarians with cognitive impairment to stay at home. Then it would follow that the lower proportion of individuals living in nursing homes would have more significant cognitive decline.

In terms of absolute figures, 256 persons in Denmark reached the age of 100 during 1995, of those 209 women and 47 men. In 2005, a total of 364 persons reached 100 years of age, 313 women and 51 men [25]. The proportion of people reaching their 100th birthday in Denmark thus increased by 42% over the course of 10 years with a distinct gender difference in favour of women compared to men. One pessimistic expectation could be that the rising number of 100-year-olds would entail a large proportion of cognitively impaired individuals in this extreme age group. On the other hand, the results of the present study do not support this expectation. Although the number of centenarians increased substantially between 1995 and 2005, the proportion with low cognitive performance stayed approximately the same. This is a positive finding compared to the study by Suzuki et al. [9] describing deteriorating trends in cognitive functioning among Okinawan centenarians. In the Okinawan study the cognitive abilities declined more among centenarians living at home than among those living in institutions. In contrast, our study showed a tendency towards better cognitive performance among home-dwelling centenarians and worse cognitive function among participants living in nursing homes.

The lack of agreement between the findings of the Okinawan study and our research may partly be due to the different mortality selection present in Denmark and Japan. It is well known that for decades, the life expectancy for both men and women has been less favourable in Denmark than in other low-mortality countries such as Japan, Spain, Italy and France. Based on the life tables for 2006/2007 the life expectancy at birth in Denmark was 75.9 years for men and 80.5 years for women, i.e. 2-4 years lower than in France (77.5 for men and 84.4 for women) [25]. Denmark experienced a stagnation in life expectancy at birth and at the age of 65 in the decades *before* 1995, primarily due to stagnating death rates among middle-aged individuals [26,27]. It was not until *after* 1995 that the life expectancy in Denmark substantially increased again [28]. The slower growth in the number of centenarians in Denmark compared to other low-mortality countries may explain the lack of deterioration of cognitive function. However, it should be stressed that the oldest-old mortality continued to decline, also during the stagnation period [27], and that the number of Danish centenarians still increased substantially between 1995 and 2005 (42%).

Our study has important strengths. Both surveys were population based and included community dwellers as well as institutionalized residents. Second, both surveys displayed a

relatively high response rate for centenarians. Third, both cohorts were shown to be unselected with regard to gender, and mean or median number of hospitalizations (data not shown). Additionally, the sex ratios in the LSDC (3.6) and the Danish 1905 cohort survey (5.3) largely correspond to those of the overall population of individuals reaching the age of 100 in Denmark in 1995 (4.4) and 2005 (6.1) [25].

The cohort comparison had some limitations. We used data from 2 surveys with some discrepancies in design and method of data collection. The LSDC enrolled and examined eligible respondents consecutively over a period of time as they reached 100 years of age. In the 1905 cohort survey the respondents were first contacted when they were 92-93 years of age and then followed up every second to third year until they reached 100 years of age. Additionally, earlier non-responders of previous waves were re-contacted in the 2005 wave.

Both surveys were conducted as in-person interviews in the respondent's own home. However, trained interviewers from the Danish Institute of Social Research carried out the 1905 cohort survey, whereas the same geriatrician and geriatric nurse made all the preparatory contacts and conducted all the interviews in the LSDC. The latter may have influenced the response rate in a positive direction. To minimize the bias, the interviewers from the Danish National Institute of Social Research conducting the most recent follow-up in the 1905 cohort were trained by the same geriatrician who carried out the LSDC.

A span of 10 years may not be enough to detect cohort differences among centenarians. However, in a previous study comparing activities of daily living between the two birth cohorts we found a significant improvement in activities of daily living among women in the 1905 cohort compared to women in the 1895 sample [4]. Thus, for activities of daily living the time frame of 10 years seems to be sufficient. In support of this, previous research conducted among younger age groups used similar or even narrower time frames [29-32], and most of these studies were able to detect significant cohort differences in favour of more recent cohorts.

Approximately 25% of the respondents in both groups were not tested with the MMSE. In the 1895 cohort this was primarily due to cognitive impairment or severe dementia [17]. Comparison of the groups not tested and those tested showed that the individuals not tested were more often living in nursing homes in both cohorts. Since the proportion of non-tested centenarians was nearly identical in both samples, this is unlikely to impact the results of the study.

We dealt with missing information on the MMSE due to visual impairment by calculating the MMSE Index. An alternative method is to make use of imputed item scores. However, this may lead to a biased result because the possibility of assigning too high scores to respondents with missing scores cannot be ruled out [23].

When using the MMSE as a brief screening test for cognitive impairment in population-based studies, age and educational level have to be taken into account [5]. Some studies show an age-related decline in MMSE scores for otherwise healthy individuals and also that individuals with higher levels of education perform better on the MMSE compared to a person of the same age with a lower educational level [33-35]. A significantly higher proportion of the men in the 1905 cohort compared to those in the 1895 cohort had more than 7 years of schooling. This may impact the results of the study, although unlikely due to the small number of males. The two cohorts were of the same age. It is therefore unlikely that age and educational level influenced the results of the study.

A potential problem of using the MMSE in repeated surveys is the introduction of a possible learning effect, i.e. longitudinal respondents may display a higher MMSE score than those who encounter the MMSE for the first time. However, in view of the time interval of 2-3 years

between the interview surveys of the 1905 cohort we consider this possibility to be very limited. Additional analyses showed no significant difference in MMSE scores for the participants encountering the MMSE for the first time in the last wave of the 1905 Cohort Survey and the subjects who had gone through repeated MMSE tests during the previous waves of the 1905 Cohort Survey (data not shown).

A pertinent issue in our study is the use of the MMSE as the only measure of cognitive function. Different findings may have been evident had there been a more extensive battery of tests with a more sophisticated instrument. However, a previous study based on the 1905 cohort using both the MMSE and a more sensitive instrument consisting of the combined score of 5 different cognitive tests, a so-called cognitive composite score (which was not used in the 1895 cohort), found that both the MMSE and the cognitive composite score were predictive of survival during the 2-year follow-up and both in the same dose-response fashion [19]. The MMSE may be a crude instrument but also appropriate in the sense that at this advanced age approximately half of the population may be more or less cognitively impaired [17].

In conclusion, this study found no significant differences in cognitive score between the two centenarian birth cohorts using the MMSE. On the other hand, in the 1905 compared to the 1895 cohort, modest tendencies were seen towards better cognitive function for the centenarians living at home and worse cognitive performance for those living in nursing homes. These tendencies may be important because in the 1905 cohort compared to the 1895 sample a slightly higher proportion of centenarians was living at home and fewer centenarians were living in nursing homes, probably a reflection of increased allocation of resources to home health care services.

Our findings suggest that the growing number of centenarians may not entail increasing proportions of cognitively impaired individuals in this extreme age group. However, had Denmark experienced a similar decline in oldest-old mortality in recent decades as that seen in Southern European countries and Japan, the findings of the study might have proved different.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

The study was supported by the US National Institute on Aging Research Grant NIA-PO1-AG08761, the Danish Health Insurance Foundation Grant 2006B139 and the Danish Interdisciplinary Research Council. The Danish Aging Research Center is supported by a grant from the VELUX foundation.

References

1. Kannisto, V. Evidence from 28 Developed Countries. Odense University Press; Odense: 1994. Development of Oldest-Old Mortality, 1950-1990.
2. Jeune B. Living longer - but better? Aging Clin Exp Res 2002;14:72–93. [PubMed: 12092789]
3. Parker MG, Thorslund M. Health trends in the elderly population: getting better and getting worse. Gerontologist 2007;47:150–158. [PubMed: 17440120]
4. Engberg H, Christensen K, Andersen-Ranberg K, Vaupel J, Jeune B. Improving ADLs among Danish centenarians - but only in women: a comparative study on two birth cohorts born in 1895 and 1905. J Gerontol A Biol Sci Med Sci. in press
5. Chatfield M, Matthews FE, Brayne C. Using the Mini-Menta State Examination for tracking cognition in the older population based on longitudinal data. J Am Geriatr Soc 2007;55:1066–1071. [PubMed: 17608880]

6. Iwasa H, Gondo Y, Furuna T, Kobayashi E, Inagaki H, Sugiura M, Masui Y, Abe T, Imuta H, Homma A, Suzuki T. Cognitive function among physically independent very old people in an urban community in Japan: the Itabashi Oldest-Old Study II. Nippon Ronen Igakkai Zasshi 2005;42:214–220. [PubMed: 15852656]
7. Schonknecht P, Pantel J, Kruse A, Schroder J. Prevalence and natural course of aging-associated cognitive decline in a population-based sample of young-old subjects. Am J Psychiatry 2005;162:2071–2077. [PubMed: 16263846]
8. Matthews FE, Miller LL, Brayne C, Jagger C. Regional differences in multidimensional aspects of health: findings from the MRC cognitive function and ageing study. BMC Public Health 2006;6:90. [PubMed: 16600044]
9. Suzuki M, Akisaka M, Ashitomi I, Higa K, Nozaki H. Chronological study concerning ADL among Okinawan centenarians. Nippon Ronen Igakkai Zasshi 1995;32:416–423. [PubMed: 7563936]
10. Franceschi C, Motta L, Valensin S, Rapisarda R, Franzone A, Berardelli M, Motta M, Monti D, Bonafe M, Ferrucci L, Deiana L, Pes GM, Carru C, Desole MS, Barbi C, Sartoni G, Gemelli C, Lescai F, Olivieri F, Marchegiani F, Cardelli M, Cavallone L, Gueresi P, Cossarizza A, Troiano L, Pini G, Sansoni P, Passeri G, Lisa R, Spazzafumo L, Amadio L, Giunta S, Stecconi R, Morresi R, Viticchi C, Mattace R, De BG, Baggio G. Do men and women follow different trajectories to reach extreme longevity? Italian Multicenter Study on Centenarians (IMUSCE). Aging (Milano) 2000;12:77–84. [PubMed: 10902049]
11. Holtsberg PA, Poon LW, Noble CA, Martin P. Mini-Mental State Exam status of community-dwelling cognitively intact centenarians. Int Psychogeriatr 1995;7:417–427. [PubMed: 8821349]
12. Martin P, Long MV, Poon LW. Age changes and differences in personality traits and states of the old and very old. J Gerontol B Psychol Sci Soc Sci 2002;57:144–152.
13. Rott C, d'Heureuse V, Kliegel M, Schonemann P, Becker G. Heidelberg Centenarian Study: theoretical and methodological principles for social science research of the oldest old. Z Gerontol Geriatr 2001;34:356–364. [PubMed: 11718098]
14. Silver MH, Jilinskaia E, Perls TT. Cognitive functional status of age-confirmed centenarians in a population-based study. J Gerontol B Psychol Sci Soc Sci 2001;56:134–140.
15. Andersen-Ranberg K, Schroll M, Jeune B. Healthy centenarians do not exist, but autonomous centenarians do: a population-based study of morbidity among Danish centenarians. J Am Geriatr Soc 2001;49:900–908. [PubMed: 11527481]
16. Folstein MF, Folstein SE, McHugh PR. `Mini-mental state': a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189–198. [PubMed: 1202204]
17. Andersen-Ranberg K, Vasegaard L, Jeune B. Dementia is not inevitable: a population-based study of Danish centenarians. J Gerontol B Psychol Sci Soc Sci 2001;56:152–159.
18. Nybo H, Gaist D, Jeune B, Bathum L, McGue M, Vaupel JW, Christensen K. The Danish 1905 cohort: a genetic-epidemiological nationwide survey. J Aging Health 2001;13:32–46. [PubMed: 11503846]
19. Andersen K, Nybo H, Gaist D, Petersen HC, McGue M, Jeune B, Vaupel JW, Christensen K. Cognitive impairment and mortality among nonagenarians: the Danish 1905 cohort survey. Dement Geriatr Cogn Disord 2002;13:156–163. [PubMed: 11893837]
20. George, LK.; Blazer, DF.; Winfield-Laird, I.; Leaf, PJ.; Fishbach, RL. Psychiatric disorders and mental health service use in later life: evidence from the Epidemiologic Catchment Area Program. In: Brody, J.; Maddox, G., editors. Epidemiology and Aging. Springer; New York: 1988. p. 189-219.
21. Reischies FM, Geiselmann B. Age-related cognitive decline and vision impairment affecting the detection of dementia syndrome in old age. Br J Psychiatry 1997;171:449–451. [PubMed: 9463604]
22. Motta M, Bennati E, Ferlito L, Malaguarnera M, Motta L. Successful aging in centenarians: myths and reality. Arch Gerontol Geriatr 2005;40:241–251. [PubMed: 15814158]
23. Fillenbaum GG, George LK, Blazer DG. Scoring nonresponse on the Mini-Mental State Examination. Psychol Med 1988;18:1021–1025. [PubMed: 3270826]
24. STATA Corporation. STATA statistical software release 8.2. STATA Corporation; College Station: 2003.
25. 2007. Statistics Denmark. Copenhagen, Statistics Denmark
26. Juel K, Bjerregaard P, Madsen P. Mortality and life expectancy in Denmark and in other European countries. What is happening to middle-aged Danes? Eur J Public Health 2000;10:93–100.

27. Jacobsen R, Keiding N, Lynge E. Long-term mortality trends behind low life expectancy of Danish women. J Epidemiol Community Health 2002;56:205–208. [PubMed: 11854342]

28. Jeune B, Brønnum-Hansen H. Trends in health expectancy at age 65 for various health indicators, 1987-2005, Denmark. Eur J Ageing. in press

29. Aijanseppa S, Notkola IL, Tijhuis M, van SW, Kromhout D, Nissinen A. Physical functioning in elderly Europeans: 10-year changes in the north and south: the HALE project. J Epidemiol Community Health 2005;59:413–419. [PubMed: 15831692]

30. Peres K, Helmer C, Letenneur L, Jacqmin-Gadda H, Barberger-Gateau P. Ten-year-change in disability prevalence and related factors in two generations of French elderly community dwellers: data from the PAQUID study. Aging Clin Exp Res 2005;17:229–235. [PubMed: 16110737]

31. Winblad I, Jaaskelainen M, Kivela SL, Hiltunen P, Laippala P. Prevalence of disability in three birth cohorts at old age over time spans of 10 and 20 years. J Clin Epidemiol 2001;54:1019–1024. [PubMed: 11576813]

32. Pitkala KH, Valvanne J, Kulp S, Strandberg TE, Tilvis RS. Secular trends in self-reported functioning, need for assistance and attitudes towards life: 10-year differences of three older cohorts. J Am Geriatr Soc 2001;49:596–600. [PubMed: 11380753]

33. O'Connor DW, Pollitt PA, Treasure FP, Brook CP, Reiss BB. The influence of education, social class and sex on Mini-Mental State scores. Psychol Med 1989;19:771–776. [PubMed: 2798645]

34. Crum RM, Anthony JC, Bassett SS, Folstein MF. Population-based norms for the Mini-Mental State Examination by age and educational level. JAMA 1993;269:2386–2391. [PubMed: 8479064]

35. Grigoletto F, Zappala G, Anderson DW, Lebowitz BD. Norms for the Mini-Mental State Examination in a healthy population. Neurology 1999;53:315–320. [PubMed: 10430420]

Table 1

Demographic characteristics of the 1895 and the 1905 cohort

	The Danish 1895 cohort			The Danish 1905 cohort		
	female	**male**	**total**	**female**	**male**	**total**
Response rate			207/276 (75)			225/364 (62)
Participants	162 (78.3)	45 (21.7)	207 (100.0)	189 (84.0)	36 (16.0)	225 (100.0)
Female/male ratio			3.6:1			5.3:1
Housing			n = 207			n = 225
At home	50 (30.9)	19 (42.2)	69 (33.3)	78 (41.3)	15 (41.7)	93 (41.3)
Nursing home	110 (67.9)	26 (57.8)	136 (65.7)	107 (56.6)	17 (47.2)	124 (55.1)
Other/unknown	2 (1.2)	0 (0.0)	2 (1.0)	4 (2.1)	4 (11.1)	8 (3.6)
Education			n = 207			n = 225
7 years or less	125 (77.2)	38 (84.4)	163 (78.7)	146 (77.3)	25 (69.4)	171 (76.0)
More than 7 years	29 (17.9)	4 (8.9)	33 (15.9)	37 (19.6)	10 (27.8)	47 (20.9)
Other/unknown	8 (4.9)	3 (6.7)	11 (5.3)	6 (3.1)	1 (2.8)	7 (3.1)
Marital status			n = 207			n = 225
Married	1 (0.6)	6 (13.3)	7 (3.4)	7 (3.7)	4 (11.1)	11 (4.9)
Not married	161 (99.4)	39 (86.7)	200 (96.6)	182 (96.3)	32 (88.9)	214 (95.1)

Figures are numbers of cases with percentages in parentheses.

Dement Geriatr Cogn Disord. Author manuscript; available in PMC 2009 August 25.

Table 2

Absolute and relative distribution of MMSE scores, by cohort and sex

	Female		Male		Total	
	1895	**1905**	**1895**	**1905**	**1895**	**1905**
Tested by MMSE					156/207 (75)	176/225 (78)
MMSE						
Median	20 [17.8-21.0]	19 [17.0-21.0]	22 [19.0-23.4]	24 [19.3-25.0]	20 [19.0-21.0]	22 [18.0-22.0]
p value[1]	0.99		0.62		0.92	
MMSE	n = 120	n = 148	n = 36	n = 28	n = 156	n = 176
24-30 points	33 (27.5)	41 (27.7)	12 (33.3)	15 (53.6)	45 (28.9)	56 (31.8)
18-23 points	38 (31.7)	44 (29.7)	14 (38.9)	7 (25.0)	52 (33.3)	51 (29.0)
0-17 points	49 (40.8)	63 (42.6)	10 (27.8)	6 (21.4)	59 (37.8)	69 (39.2)
p value[2]	0.94		0.29		0.66	
MMSE Index	n = 120	n = 148	n = 36	n = 28	n = 156	n = 176
0.81-1.0	29 (24.2)	38 (25.7)	10 (27.8)	12 (42.9)	39 (25.0)	50 (28.4)
0.63-0.80	40 (33.3)	46 (31.0)	15 (41.7)	9 (32.1)	55 (35.3)	55 (31.2)
0.40-0.62	27 (22.5)	38 (25.7)	7 (19.4)	3 (10.7)	34 (21.8)	41 (23.3)
0.0-0.39	24 (20.0)	26 (17.6)	4 (11.1)	4 (14.3)	28 (17.9)	30 (17.1)
p value[2]	0.89		0.53		0.83	

Figures are numbers of cases with percentages in parentheses. Values in square brackets represent 95% CI. MMSE Index: cut points described in Motta et al. [22]: 0.81-1.00 = no cognitive impairment, 0.63-0.80 = slight signs of cognitive impairment, 0.40-0.62 = moderate cognitive impairment, 0-0.39 = severe cognitive impairment. According to Motta et al. the `slight signs of cognitive impairment' and the `no cognitive impairment' groups are considered in the normal range established for the elderly.

[1] As obtained by the Wilcoxon rank sum test.

[2] As obtained by Fisher's exact test.

Dement Geriatr Cogn Disord. Author manuscript; available in PMC 2009 August 25.

Table 3

Absolute and relative distribution of MMSE score, by housing and sex

	Living at home						Nursing home and sheltered housing					
	women		men		total		women		men		total	
	1895	1905	1895	1905	1895	1905	1895	1905	1895	1905	1895	1905
MMSE	n = 40	n = 71	n = 19	n = 13	n = 59	n = 84	n = 80	n = 75	n = 17	n = 11	n = 97	n = 86
24-30 points	15 (37.5)	26 (36.6)	4 (21.0)	10 (76.9)	19 (32.2)	36 (42.8)	18 (22.5)	13 (17.4)	8 (47.1)	4 (36.4)	26 (26.8)	17 (19.8)
18-23 points	12 (30.0)	22 (31.0)	9 (47.4)	1 (7.7)	21 (35.6)	23 (27.4)	26 (32.5)	22 (29.3)	5 (29.4)	4 (36.4)	31 (32.0)	26 (30.2)
0-17 points	13 (32.5)	23 (32.4)	6 (31.6)	2 (15.4)	19 (32.2)	25 (29.8)	36 (45.0)	40 (53.3)	4 (23.5)	3 (27.2)	40 (41.2)	43 (50.0)
p value	1.00		0.006		0.40		0.57		0.89		0.43	

Figures are numbers of cases with percentages in parentheses. p value: as obtained by Fisher's exact test.

Table 4

Number of participants who could perform a complete or incomplete MMSE, according to different reasons

	Complete examination		Reasons for incomplete examination										All	
			visual impairment		hearing impairment		refusal of 1 or more items		other reasons		incomplete examination			
	1895	1905	1895	1905	1895	1905	1895	1905	1895	1905	1895	1905	1895	1905
Proportion	72/156 (46.2)	81/176 (46.0)									84/156 (53.8)	95/176 (54.0)		
MMSE	n = 72	n = 81									n = 84	n = 95	n = 156	n = 176
24-30	32 (44.4)	43 (53.1)	11	8	0	0	2	6	1	3	13 (15.5)	13 (13.7)	45 (28.8)	56 (31.8)
18-23	25 (34.7)	27 (33.3)	16	14	10	6	9	14	3	6	27 (32.1)	24 (25.3)	52 (33.3)	51 (29.0)
0-17	15 (20.8)	11 (13.6)	26	28	8	23	18	36	8	36	44 (52.4)	58 (61.0)	59 (37.8)	69 (39.2)
p value	0.41										0.50		0.66	

Some of the participants had more than 1 reason for not completing the examination. Figures are numbers of cases with percentages in parentheses. Other reasons: 1895 cohort: no specific reasons defined. 1905 cohort: paralysis, could not understand the instructions, impairment of speech or other non-specified reason. p value: as obtained by Fisher's exact test.