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Improving Activities of Daily Living in Danish Centenarians—But Only in Women: A Comparative Study of Two Birth Cohorts Born in 1895 and 1905

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Abstract

Background—The number of centenarians has increased rapidly since the 1950s. In Denmark, 42% more of the 1905 birth cohort made it to 100 years of age compared to the 1895 cohort. We tested whether this increased survival proportion has resulted in an increased disability level in the more recent cohort of centenarians.

Methods—The Longitudinal Study of Danish Centenarians (LSDC) included all persons who reached the age of 100 years in the period from April 1, 1995 through May 31, 1996 (a total of 276 persons). In total, 207 persons participated in the survey (75%). The Danish 1905 Cohort Survey included all individuals born in Denmark in 1905. At baseline in 1998, a total of 2262 persons participated in the intake survey (63%). In total, 225 of 364 persons (62%) who reached their 100th birthday in the cohort participated in the most recent 2005 wave. Basic Activities of Daily Living (BADLs) and Physical Activities of Daily Living (PADLs) were assessed in both cohorts.

Results—The 1905 cohort displayed better self-reported ADLs than the 1895 cohort did. Stratified by gender, this apparent cohort advantage was due to women in the 1905 cohort performing significantly better than their female counterparts in the 1895 cohort.

Conclusion—The increasing number of female centenarians does not entail increasing proportions of disabled individuals. In contrast, there is a lack of improvement in ADLs among male centenarians even though the number of male centenarians is stagnating.

Keywords

Centenarians; Activities of Daily Living; Cohort comparisons

In recent decades western developed countries have witnessed decreasing mortality rates among the older population (1,2). The rapid growth of the oldest-old population and increases in exceptional longevity have led to an ongoing debate whether longer lives are accompanied by longer active lives that are free from disability (3). Increasing numbers of centenarians may be associated with large proportions of oldest-old persons suffering from disability and poor health, and eventually an increasing need for medical care and treatment (4). The trends in

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health and disability prevalence among tomorrow's oldest-old population, therefore, have obvious implications for the planning and delivery of future health care and social services.

Mortality and morbidity in addition to disability and loss of function are the four main health dimensions used in most research on trends in health among elderly persons. Depending on which health dimension one is studying, health trends may go in different directions (5). Most studies show declining disability rates in recent cohorts (5–10), but some find no decline or even increasing trends of disability (11,12). The only study at present examining cohort changes in physical functioning among centenarians showed an increase in disability levels among Okinawan centenarians from the 1970s through the 1990s (13).

In the present study we compared Basic Activities of Daily Living (BADLs) and Physical Activities of Daily Living (PADLs) in two birth cohorts of centenarians born 10 years apart. We tested whether the increased survival proportion of centenarians has resulted in an increased disability level in the more recent cohort. The study also focused on differential trends according to gender and housing.

METHODS

Study Population

The study was based on two Danish centenarian cohorts born in 1895–1896 and 1905. The Longitudinal Study of Danish Centenarians (LSDC) comprises all individuals reaching the age of 100 years in the period from April 1, 1995 through May 31, 1996. A total of 207 of 276 eligible centenarians identified through the Danish Civil Registration System (DCRS) participated in the intake survey (75%). A nonresponse analysis showed no difference between responders and nonresponders with respect to gender, housing, and mean number of hospitalizations in the last 18 years (4). The same geriatrician and geriatric nurse visited all of the respondents. The interview consisted of sociodemographic variables, health, and self-reported ADL. Since the baseline survey, in-person follow-ups have been conducted once every year. The study was approved by The Scientific-Ethical Committee of the Counties of Funen and Vejle, Odense, Denmark (trial numbers: 95/93 and 95/93MC). The study has been described in detail by Andersen-Ranberg and colleagues (4).

The Danish 1905 Cohort Survey is a nationwide longitudinal survey consisting of all individuals born in Denmark in 1905 identified through the DCRS. At baseline in 1998, a total of 3600 persons 92–93 years old were still alive in the cohort, and 2262 of these persons participated in the intake survey (63%). The baseline interview and successive follow-ups consisted of a personal interview in the respondents' home and included information on socio-demographic variables, health, and self-reported ADLs. Trained interviewers from the Danish National Institute of Social Research carried out the survey. Since then, in person follow-ups have been conducted every 2–3 years, the most recent one taking place in 2005 when the survivors could celebrate their 100th birthday. A total of 166 individuals participated in the 2005 follow-up. To increase the number of participants, all survivors including earlier nonresponders were contacted again. This contact yielded another 90 participants, increasing the total number of respondents in the last wave to 256. Not every respondent had reached the age of 100 at the time of the 2005 interview. In this cohort comparison, we included only those participants who reached their 100th birthday before death, in total 225 of 364 eligible respondents (62%). Information on gender, hospitalizations, and number of hospital days was available for all 364 eligible individuals in the 1905 cohort using the DCRS and the Danish National Register of Patients (in existence since 1977). A nonresponse analysis showed no difference between responders and nonresponders with respect to gender (women, 84% vs 89%, $p = .16$), median number of hospitalizations ($p = .56$), or median number of bed days ($p = .71$) during the years 2003 and 2004 (data not shown). The Danish 1905 Cohort Survey has

been described in detail elsewhere (14). The Ethical committee system in Denmark approved the study (trial number VF20040240).

Measures

Housing—was a binary variable reflecting whether the respondent was living at home or in a nursing home. The nursing home group also included participants living in sheltered institutions with substantial help.

Educational level—was a binary variable reflecting whether the respondent had ≤7 years or >7 years of schooling.

Marital status—was divided into two groups reflecting whether the respondent was married or not married. Divorced or separated respondents were assigned to the nonmarried group.

Disability—was self-reported and assessed using two different scales. BADLs were assessed using a modified version of the Katz Index of Independence in Activities of Daily Living (Katz ADL) (15,16). The Katz ADL assesses BADLs such as bathing, dressing, toileting, transferring, continence, and feeding. Continence was not included in the present analysis because only one of the cohorts was asked about that particular item. Thus, a comparison between the cohorts with respect to continence was not possible.

PADLs were assessed according to Avlund's Physical Activities of Daily Living Scale (17, 18). In origin, the scale consists of 16 items relating to more complex ADLs. Because of an overlap of BADLs and PADLs, only 10 PADL items were included in this analysis (see Figure 3 and Figure 4).

BADL and PADL items were dichotomized into yes and no variables. Independence was defined within each item as the ability to perform the activity completely by oneself or with the use of assistive devices. Neither personal assistance nor indirect help such as guidance was allowed. The prevalence of independence in the two cohorts was compared for each of the BADL and PADL items separately. Also, respondents were grouped according to the number of BADL items that they were able to perform independently.

The use of assistive devices was assessed by our asking the respondents to indicate whether they used glasses, hearing aid, cane, crutches, walker, wheelchair, elevated toilet seat, handle/handgrip, bathing chair, and/or balcony frame in their daily life. Answer categories were yes and no.

Data Analysis

Differences between the cohorts on categorical variables were tested using the chi-square test. A p value of <.05 was considered to indicate statistical significance. All analyses were performed separately for men and women to detect possible gender differences. Data were analyzed using the STATA Statistical Software Package [version 8.2; Stata Corporation (19)].

RESULTS

Women outnumbered men in both cohorts, and over time an increasing trend was evident (Table 1). In the 1895 cohort the female-to-male ratio was 3.6 whereas in the 1905 cohort the ratio was 5.3. These sex ratios largely correspond to those of the overall population of individuals reaching their 100th birthday in 1995 (4.4) and 2005 (6.1) obtained from Statistics Denmark and the DCRS (20). The cohorts did not differ significantly with regard to housing,

educational level, or marital status. However, a higher proportion of women were living at home in the 1905 cohort (41% vs 31%).

With regard to BADLs, a significantly higher proportion of female centenarians in the 1905 cohort compared to the 1895 cohort were independently able to take a bath, get dressed, go to the toilet, and eat without help (Figure 1). No systematic differences between birth cohorts were seen among men (Figure 2). In PADLs, the prevalence of independence was significantly higher among women in the 1905 cohort in all but one item (i.e., the ability to wash the upper part of the body) (Figure 3). There were no systematic differences among men (Figure 4). When sex differences in BADLs and PADLs were examined within the two birth cohorts, men compared to women in the 1895 cohort performed significantly better in most items. However, in the 1905 cohort these significant sex differences largely disappeared (data not shown).

Table 2 depicts that a significantly higher proportion of female centenarians in the 1905 cohort were able to perform all of the five BADL items independently (21% vs 10%, $p = .008$). No significant differences were seen among men.

Among female centenarians living at home, the prevalence of independence was significantly higher in the 1905 cohort compared to the 1895 cohort in all ADL items. Among women living in nursing homes, the younger cohort was only significantly less disabled in dressing, getting outdoors, and walking on stairs (Table 3).

In both sexes, the proportion of centenarians using common assistive devices such as a walker, an elevated toilet seat, handles or hand grip, or a bathing chair was significantly higher in the 1905 cohort than in the 1895 cohort (Table 4). However, focusing exclusively on women, among those who did not use assistive devices, the proportion being independent in taking a bath, going to the toilet, getting outdoors, and walking on stairs was significantly higher in the 1905 cohort compared to the 1895 cohort (Table 5).

DISCUSSION

This study is among the first to examine cohort changes in physical functioning among centenarians. Women in the 1905 cohort experienced lower self-reported disability levels than women in the 1895 cohort. No systematic cohort differences were seen among male centenarians. Stratified by housing, especially a higher proportion of home-dwelling women in the 1905 cohort were nondisabled. Although the use of common assistive devices was significantly higher in the 1905 cohort, a higher proportion of women in the 1905 cohort were able to perform selected ADLs without the use of assistive devices.

The results of the study do not corroborate the study by Suzuki and colleagues (13). An earlier consensus report (21) noted that, only after 1990 in the United States, consistent declines in disability levels were seen among the oldest segment of the population. Because Suzuki and colleagues studied older cohorts of centenarians, this may in part explain the discrepancy between the results of the Okinawan study and this present cohort comparison.

The study had important strengths. First, both surveys were population based with no exclusion criteria used. Second, both surveys displayed relatively high response rates, and third, both cohorts were shown to be unselected regarding gender and mean or median number of hospitalizations.

Very few ADL items were exposed to missing responses. In the 1895 cohort there were no missing responses, and in the 1905 cohort missing responses to 13 of 15 ADL items ranged from 0%–1.3%. Forty-two women and nine men did not answer the remaining two items: the ability to get outdoors, and to walk on stairs. A sensitivity analysis did not change the

conclusion of women in the 1905 cohort experiencing a significantly higher prevalence of independence in both items (results not shown).

The cohort comparison had some limitations. We used data from two 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, respondents were first contacted when they were 92–93 years old, and then followed-up until they reached 100 years of age. Additionally, all survivors including earlier nonresponders were contacted again in the most recent 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 preparatory contacts and conducted all interviews in the LSDC. The latter may have yielded a higher proportion of disabled centenarians in the oldest cohort.

Disability was self-reported, and may to some extent depend on the professional level of the interviewer. For example, skilled professionals may be able to more precisely pinpoint the ADL level of the respondent than nonskilled interviewers may be. Because the professional skills of the interviewers differed between surveys, this may have influenced the self-reported disability levels. To minimize this kind of bias, the interviewers from the Danish National Institute of Social Research conducting the 2005 survey in the 1905 cohort were trained by the same geriatrician who carried out the LSDC.

According to Table 2, a sensitivity analysis was performed in which all female nonresponders in both cohorts were coded as moderately or severely disabled. Coding the nonresponders as disabled did not alter the result that female centenarians in the 1905 cohort were more independent than their female counterparts in the 1895 cohort ($p = .049$).

In Denmark, the number of people reaching the age of 100 years has increased by 42% from 1995 to 2005. Clear gender disparities in favor of women compared to men underlie this growth in centenarians. During 1995, a total of 209 women and 47 men, compared to 313 women and 51 men in 2005, lived to celebrate their 100^{th} birthday (20). Thus, although the number of female centenarians has increased by approximately 50% over the course of a decade, a modest increase of only 9% has been evident among men in the same period of time.

The ability to perform ADLs had not improved among men, and several reasons may explain this. First, a timeframe of 10 years may be too short to detect any cohort advances in disability levels among male centenarians. However, because a clear improvement in disability levels was seen among women, the timeframe of 10 years seems to be sufficient concerning the health dimension of disability. Second, it could be that not enough men participated in the surveys to detect a statistically significant difference in favor of the 1905 cohort. This seems unlikely, because in the 1895 cohort significant differences between men and women could be seen in most ADL items, whereas in the 1905 cohort these significant sex differences had largely disappeared. In addition, there were no systematic tendencies in the proportion of men in the 1905 cohort reporting better ADL than those reported by men in the 1895 cohort. Third, the lack of improvement in disability levels among men could be due to men using assistive devices disproportionately less than women. However, the relative increase in the use of assistive devices was approximately the same for men and women in the 1905 cohort. Nevertheless, because of the relatively small male number, one should be careful in generalizing the lack of improvement among male centenarians to other centenarian populations.

Cohort advances in disability may be due to a higher proportion of centenarians in the 1905 cohort using assistive devices. Disability can be seen as the gap between an individual's capacity and environmental demand (22), and may thus be amenable to changes in capacity

and changes in environment. One example of change in the environment is an increased use of assistive devices. We therefore examined disability trends for selected ADL items among women who did and did not use assistive devices. Within both groups, the 1905 cohort experienced a higher prevalence of independence, although it was more pronounced among women who did not use assistive devices. The latter may reflect a real improvement in capacity either due to better prevention, for example, through the beneficial effects of physical activity and exercise even among very old people, and/or due to better medical care of the 1905 cohort.

Conclusion

This study indicates that recent cohorts of female centenarians are fitter than previous ones with respect to ADL. Because women clearly and continuously outnumber men among the oldest-old population, and the level of disability in this study had improved systematically among the younger cohort of female centenarians, there is reason to adopt a positive view to the increasing number of female oldest-old. In contrast, there was a lack of improvement in ADLs among male centenarians even though the number of male centenarians is stagnating. The study suggests that the factors influencing the increased survival among women compared to men also influences disability levels in a very positive direction. Increased survival and lower disability levels may have common causes, stemming from both preventive strategies and better treatment options among the oldest-old population.

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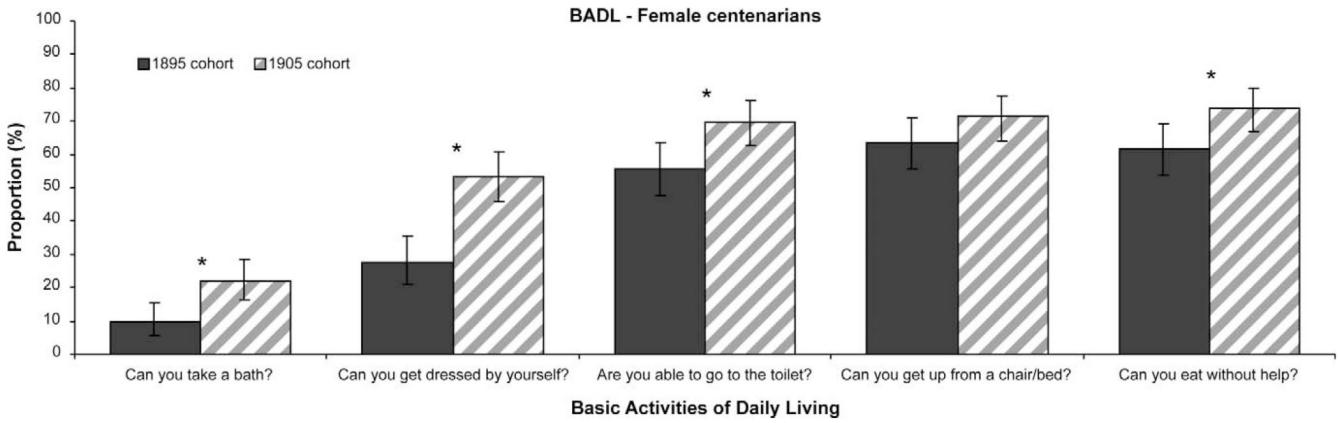

Figure 1.

The proportion of female centenarians independent in Basic Activities of Daily Living (BADL) (self-reported). Bars and error bars: proportions and 95% confidence intervals. *$p < .05$ as obtained by the chi-square test.

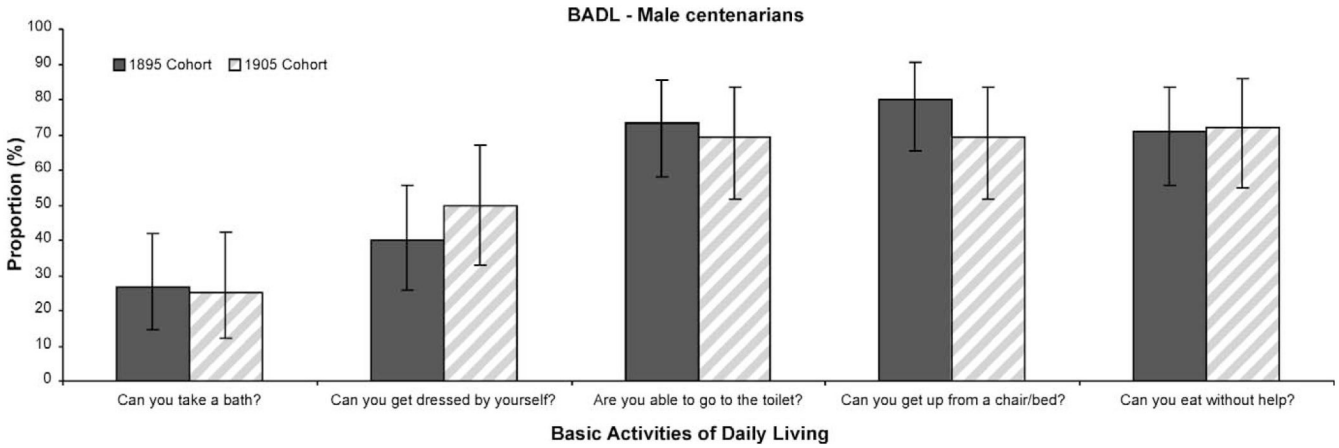

Figure 2.

The proportion of male centenarians independent in Basic Activities of Daily Living (BADL) (self-reported). Bars and error bars: proportions and 95% confidence intervals. *$p < .05$ as obtained by the chi-square test.

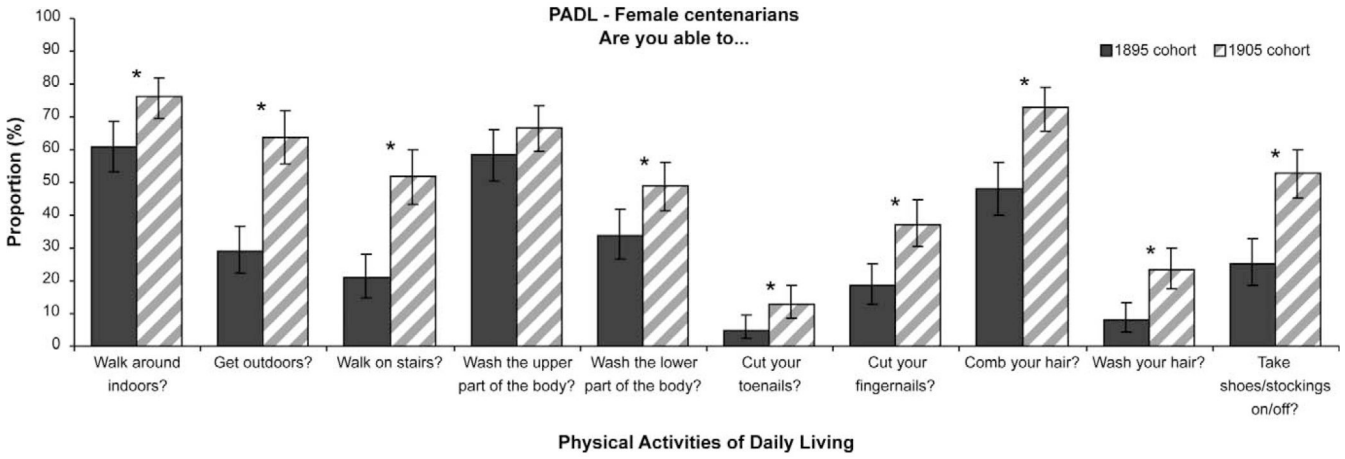

Figure 3.

The proportion of female centenarians independent in Physical Activities of Daily Living (PADL) (self-reported). Bars and error bars: proportions and 95% confidence intervals. *$p < .05$ as obtained by the chi-square test.

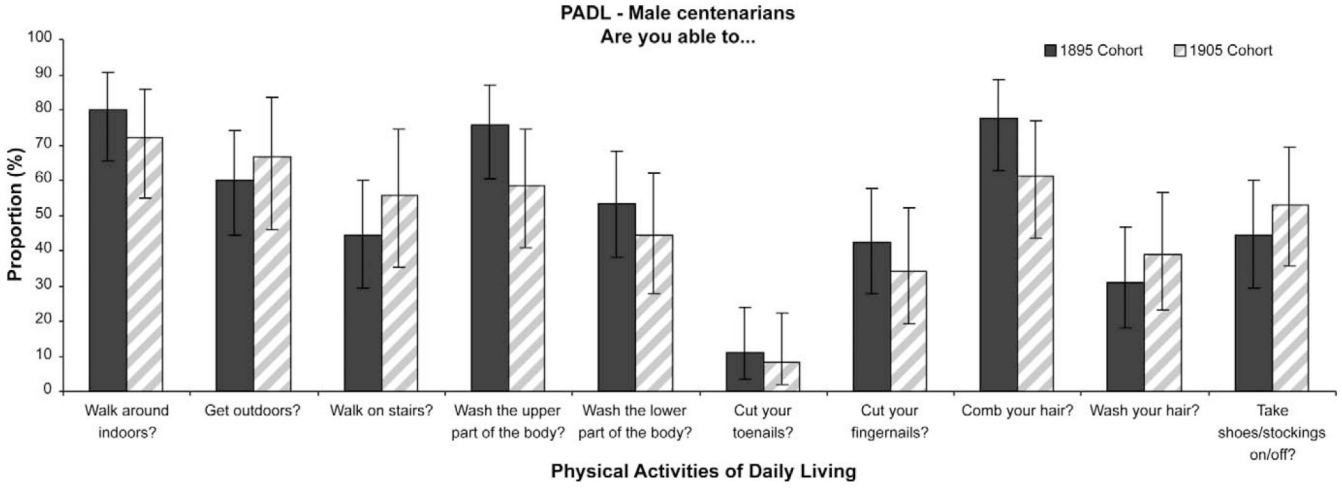

Figure 4.

The proportion of male centenarians independent in Physical Activities of Daily Living (PADL) (self-reported). Bars and error bars: proportions and 95% confidence intervals. *$p < .05$ as obtained by the chi-square test.

Table 1

Demographic Characteristics of the 1895 Cohort and the 1905 Cohort

	The Danish 1895 Cohort			The Danish 1905 Cohort		
	Sex			Sex		
Characteristic	Women *n* (%)	Men *n* (%)	Total *N* (%)	Women *n* (%)	Men *n* (%)	Total *N* (%)
Response rate			207/276 = 75%			225/364 = 62%
No. of 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)
Educational level			*n* = 207			*n* = 225
≤7 years	125 (77.2)	38 (84.4)	163 (78.7)	146 (77.3)	25 (69.4)	171 (76.0)
>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)

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Table 2

Number of Self-Reported BADLs Performed Independently, by Sex

	Women		Men	
	1895 Cohort	**1905 Cohort**	**1895 Cohort**	**1905 Cohort**
BADLs performed independently, *n* (%)	*N* = 162	*N* = 189	*N* = 45	*N* = 36
5 (Nondisabled)	16 (9.9)	39 (20.6)	12 (26.7)	8 (22.2)
3 or 4 (Moderately disabled)	67 (41.4)	81 (42.9)	19 (42.2)	14 (38.9)
0–2 (Severely disabled)	79 (48.8)	69 (36.5)	14 (31.1)	14 (38.9)
p value*	*p* = .008		*p* = .75	

**Notes:* As obtained by the chi-square test.

BADLs = Basic Activities of Daily Living.

Table 3

Proportion of Female Centenarians Independent in Selected BADL and PADL Functions, by Housing and Cohort

	Living at Home		Living in Nursing Home		Test of Cohort Differences*	
	1895 Cohort	1905 Cohort	1895 Cohort	1905 Cohort	Living at Home	Living in Nursing Home
Activities of daily living†	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*p* Value	*p* Value
Can you take a bath?	10 (20.0)	31 (40.8)	6 (5.5)	9 (8.5)	.02	.38
Can you get dressed by yourself?	23 (46.0)	61 (79.2)	21 (19.1)	36 (34.3)	<.001	.01
Are you able to go to the toilet?	38 (76.0)	71 (92.2)	51 (46.4)	58 (54.2)	.01	.25
Can you get up from a chair/ bed?	38 (76.0)	71 (92.2)	64 (58.2)	61 (57.0)	.01	.86
Can you eat without help?	36 (72.0)	70 (90.9)	63 (57.3)	65 (61.3)	<.01	.55
Are you able to walk around indoors?	37 (74.0)	72 (93.5)	61 (55.5)	68 (63.6)	<.01	.23
Are you able to get outdoors?‡	20 (40.0)	51 (70.8)	26 (23.6)	40 (55.6)	<.01	<.001
Are you able to walk on stairs?‡	21 (42.0)	49 (68.1)	12 (10.9)	25 (34.7)	<.01	<.001

**Notes*: As obtained by the chi-square test.

†Proportion answering yes to the question (assistive devices allowed).

‡Information missing for 42 women in the 1905 cohort.

BADL = Basic Activity of Daily Living; PADL = Physical Activity of Daily Living.

Table 4

Proportion of Centenarians Using Assistive Devices, by Sex and Cohort

	Women		Men		Test of Cohort Differences*	
Ordinarily, do you use any of the following aids?†	**1895 Cohort *N* (%)**	**1905 Cohort *N* (%)**	**1895 Cohort *N* (%)**	**1905 Cohort *N* (%)**	**Women *p* Value**	**Men *p* Value**
Glasses	133 (82.1)	155 (82.5)	42 (93.3)	26 (72.2)	.93	.01
Hearing aid	84 (51.6)	107 (56.6)	27 (60.0)	23 (63.9)	.37	.72
Cane	37 (22.8)	63 (33.7)	27 (60.0)	13 (36.1)	.03	.03
Crutches	7 (4.3)	7 (3.7)	4 (8.9)	3 (8.3)	.78	.93
Walker	75 (46.3)	126 (67.4)	13 (28.9)	20 (55.6)	<.001	.02
Wheelchair	52 (32.1)	62 (33.3)	8 (17.8)	15 (41.7)	.81	.02
Elevated toilet seat	22 (13.6)	81 (43.6)	5 (11.1)	18 (50.0)	<.001	<.001
Handle/handgrip	15 (9.3)	100 (53.8)	3 (6.7)	21 (58.3)	<.001	<.001
Bathing chair	35 (21.6)	121 (65.4)	12 (26.7)	21 (58.3)	<.001	<.01
Balcony frame	54 (33.3)	45 (24.2)	8 (17.8)	18 (50.0)	.06	<.01

**Notes*: As obtained by the chi-square test.

†Proportion answering yes to the question.

Table 5

Proportion of Female Centenarians Independent in Selected Activities of Daily Living (ADL) and Mobility Functions, by the Use of Assistive Devices

Activities of Daily Living[†]	With Assistive Devices		Without Assistive Devices		Test of Cohort Differences[*]	
	1895 Cohort *N* (%)	1905 Cohort *N* (%)	1895 Cohort *N* (%)	1905 Cohort *N* (%)	With Assistive Devices *p* Value	Without Assistive Devices *p* Value
Can you take a bath?[‡]	5 (11.9)	19 (13.4)	11 (9.2)	21 (51.2)	.80	<.001
Are you able to go to the toilet?[§]	20 (57.1)	79 (66.4)	70 (55.1)	49 (75.4)	.32	<.01
Are you able to walk around indoors?[//]	79 (79.8)	125 (86.8)	20 (31.8)	17 (39.5)	.14	.41
Are you able to get outdoors?[//]	39 (39.4)	79 (61.2)	8 (12.7)	14 (82.4)	.001	<.001
Are you able to walk on stairs?[¶]	16 (43.2)	40 (66.7)	18 (14.4)	36 (41.9)	.02	<.001

[*] *Notes*: *As obtained by the chi-square test.

[†] Proportion answering yes to the question.

[‡] Assistive devices are handle/handgrip or bathing chair.

[§] Assistive devices are handle/handgrip or elevated toilet seat.

[//] Assistive devices are walker or cane.

[¶] Assistive device is cane.

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