

Declining Trends in Blood Pressure Levels and Prevalence of Hypertension in Atomic Bomb Survivors in Nagasaki, Japan, 1971-1991

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The annual trends in blood pressure levels and prevalence of hypertension classified by JNC-5 were investigated. This survey was conducted retrospectively in a large cohort of Nagasaki atomic bomb survivors (78,323 persons in 1971) over 20 years. In the age-sex specific groups from the 30's to the 90's, the levels of mean SBP decreased in the latter 10 years compared to the former 10 years except in males in the 30's and the mean DBP decreased except in both sexes in the 30's. The annual trends in age-sex specific mean SBP and DBP were observed in a significant downward fashion and the most conspicuous depletion was shown at the age 80's in males, 8.3 mmHg per 10 years for SBP and 3.0 mmHg per 10 years for DBP.

The prevalence of high blood pressure has decreased. The depletion was most striking in the severe (stage 3) and very severe (stage 4) groups of JNC-5 classification. In all sex-age groups, the proportion of stage 3 decreased to the level below one-third or even one quarter compared to the maximum rate in the study period. The depletion of the stage 4 group was most conspicuous, for example, from 3% in 1975 to 0.38% in 1989 in the 80's male group.

Introduction

Numerous investigations have revealed an increased risk of stroke, congestive heart failure and ischemic heart disease in elderly hypertensive persons.¹⁾²⁾ Furthermore, active treatment for hypertension has reduced mortality and morbidity in hypertensive subjects.³⁾⁴⁾ A substantial proportion of adults suffered from hypertension and the progressive increase in blood pressure with age is widely noticed in Japan as well as in Western countries.⁵⁾⁷⁾ Utilizing WHO criteria (SBP \geq 160 mmHg and/or DBP \geq 95 mmHg), approximately 40% of persons aged 65 years or older have this condition.⁸⁾ The proportion of aged people is now increasing rapidly in Japan and the persons aged 65 years or more will be 20% of all Japanese population in the year of 2000 and 25% in 2020. Therefore, preventive measures and treatment for hypertension are now becoming more important. From clinical and public viewpoint, it is also essential to apprehend the changes in

blood pressure levels and the prevalence rate of hypertension over the past year by sex and age. The purpose of this study is to investigate the age- and sex-specific trends in mean systolic and diastolic blood pressure and prevalence of high blood pressure during the past 20 year (April 1971-March 1991) in Nagasaki atomic bomb survivors.

Subjects and Methods

The subjects were approximately 78,000 atomic bomb survivors (78,323 persons in 1971 and 63,165 persons in 1991) registered at the Scientific Data Center of Atomic Bomb Disaster, Nagasaki University, and their offsprings selected randomly. Each subject was requested to visit the A-bomb Casualty Council Medical Center twice a year for medical examination and approximately 38% of the subjects complied. Consequently, the total number of blood pressure measurements was 1,833,264 (male: 641,590, female: 1,191,674) in the entire study period. Annual change in number of cohorts is shown in Table 1. A gradual reduction is observed because of the sum of deaths and emigrants from Nagasaki City exceeded that of new entry and transfer from other districts every year. The blood pressure was measured at the right arm in the sitting position with a mercury sphygmomanometer.

Results

The 20-year study period was divided into 2 terms, April 1971 to March 1981 and April 1981 to March 1991. The mean systolic and diastolic blood pressures in each term are shown by age and sex in Fig. 1.

In males and females, an increase of mean SBP with age was evident until at least 80's in both terms. In the 1st term, the systolic pressure in males consistently rose from 126 mmHg in the 30's to the maximum level of 153 mmHg in the highest age group of the 90's. In females, the rising was from 118 mmHg in the 30's to the maximum value

153 mmHg in the 80's. Compared to the 1st term, the systolic pressure in the latter term was low in all age groups except in males in the 30's. The magnitude of decline was larger for the older age groups than for the

younger age groups. The maximum reduction was 8.1 mmHg in males in the 70's and 7.5 mmHg in females in the 60's (Fig. 2).

DBP changes with age were somewhat different from

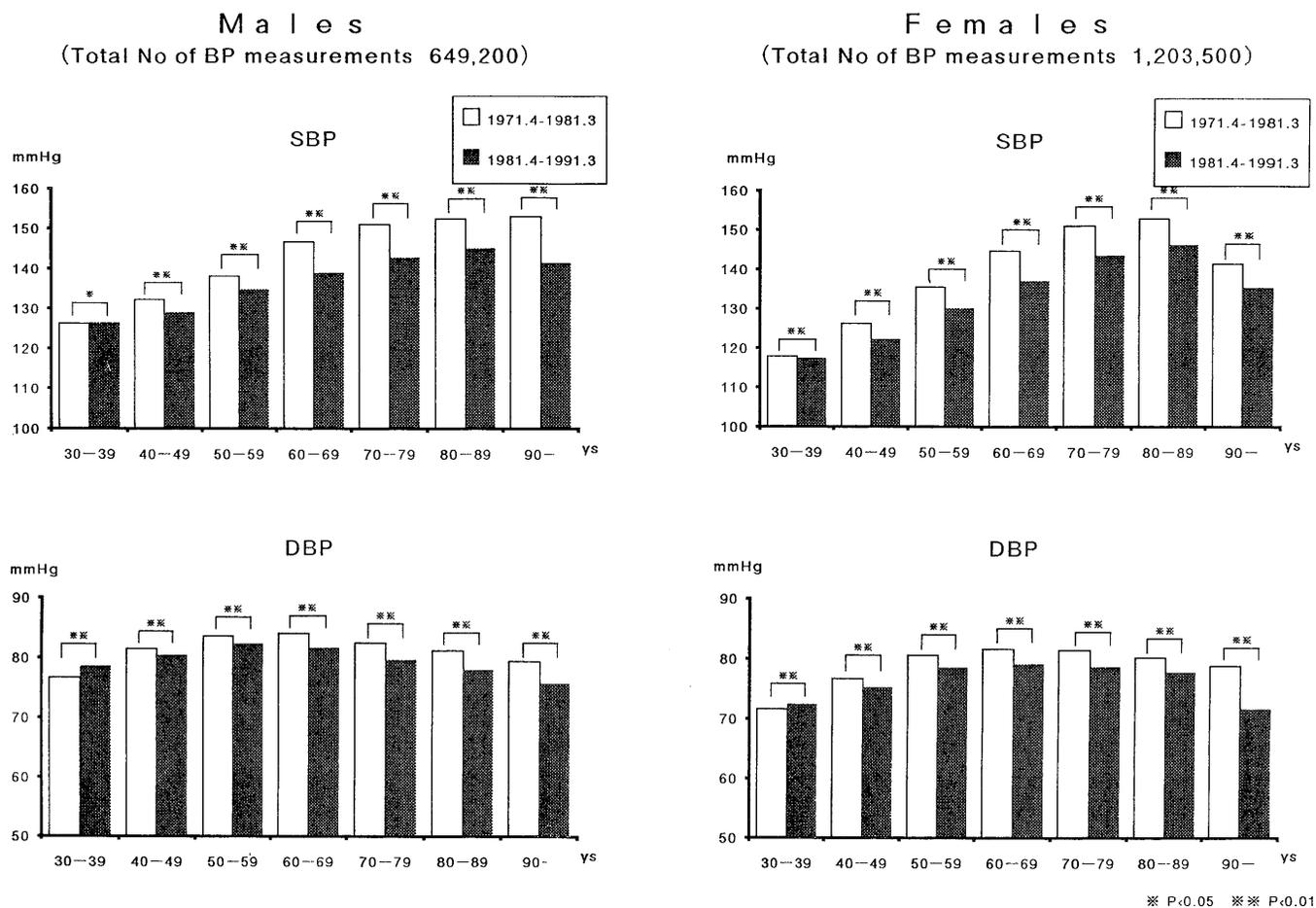


Fig. 1 Mean systolic and diastolic blood pressures by sex and age group

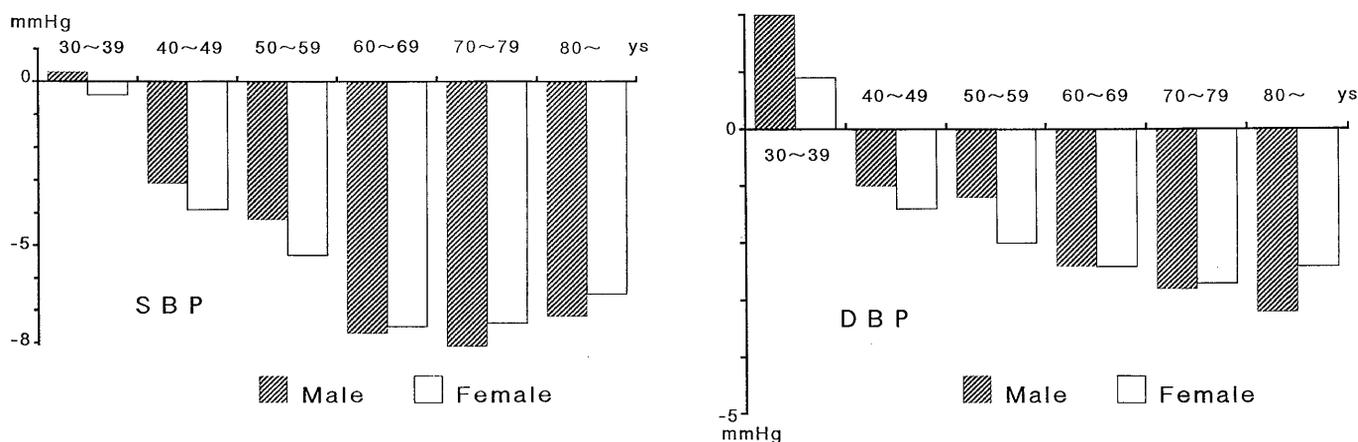


Fig. 2 BP changes between the 1st and 2nd terms

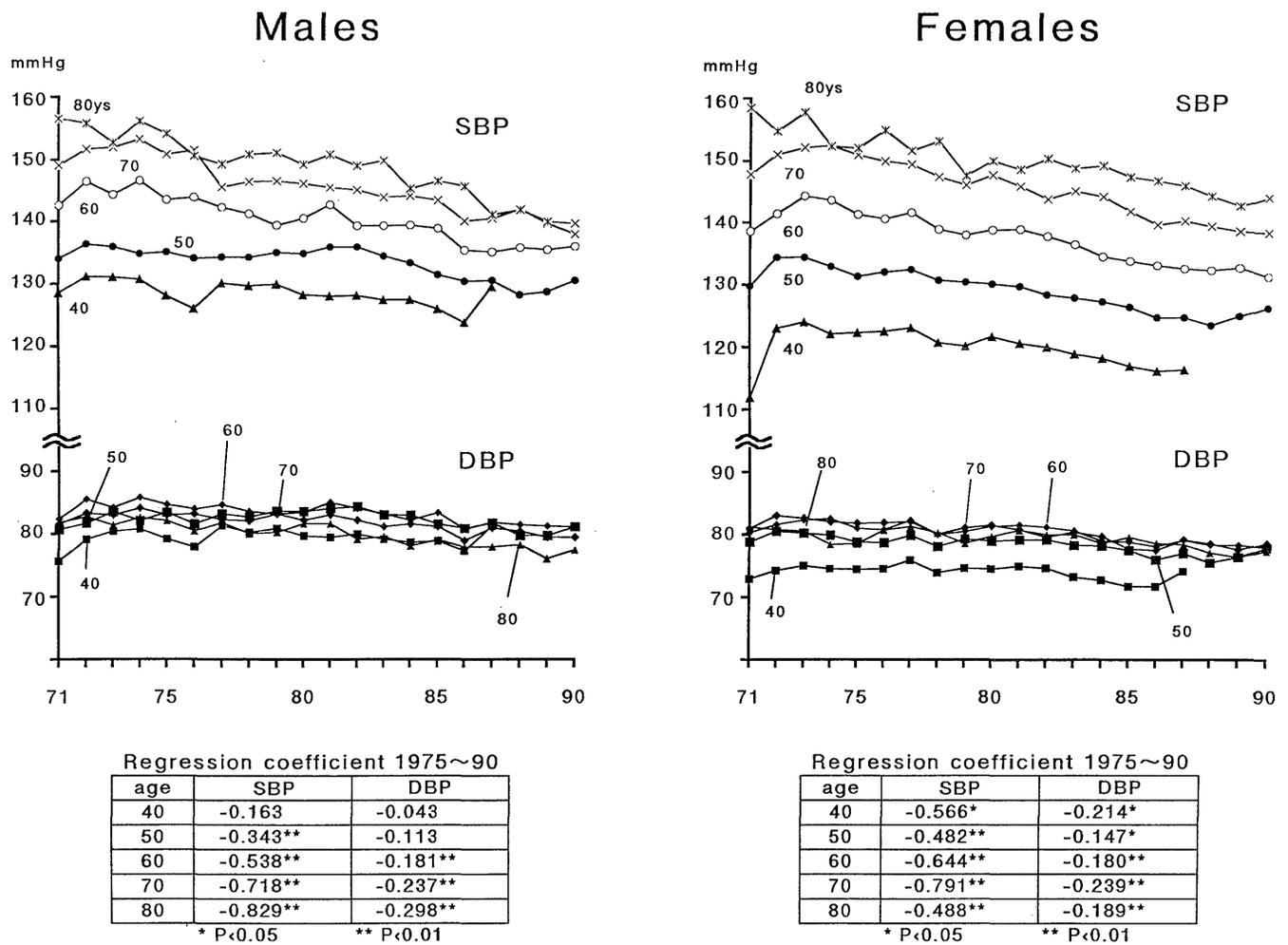


Fig. 3 Mean systolic and diastolic blood pressures by sex and age group

those of systolic pressure. The peak of diastolic pressure was seen in somewhat younger groups. In males, the highest pressure was shown in the 50's and the 60's in both terms. In females, the peak values were obtained in the 50's and the 80's in both terms. The magnitude of diastolic pressure depletion in the 2nd term compared to the 1st term also revealed a consistent acceleration with age. However, the degree of acceleration was generally smaller than the systolic pressure. The maximum decline of 3.2 mmHg was observed in males in the 80's (Fig. 2).

Age-specific mean SBP and DBP by sex are shown in Fig. 3. The trend analysis revealed a slight decline in SBP and a more trivial decline in DBP in both sexes in age groups of 40, 50, 60, 70 and 80 years over the past 15 years (from 1975 to 1990). However, even apparent increases were noted in some age groups of both sexes between 1971 to 1975. The regression coefficients for the trend in SBP and DBP for both sexes during the period of 1975 to 1990 are shown at the bottom of Fig. 3. In females, all trends for SBP and DBP in each age group were observed in a

significant downward fashion ($p < 0.05$ and $p < 0.01$). The most striking depletion was shown at age of 70, 7.9 mmHg per 10 years for SBP 2.4 mmHg per 10 year for DBP. In males, the SBP and DBP also decreased significantly in the age groups of 50 years or more except DBP at age 50, and the grade of changes in systolic and diastolic pressures became larger with advancing age; the maximum of 8.3 mmHg SBP depletion per 10 year and 3.0 mmHg DBP depletion at age 80.

The annual proportion of the subjects with $SBP \geq 160$ mmHg which was subdivided into 160-180 mmHg and 185-219 mmHg over the 20-year study period is presented in Fig. 4-a. The prevalence was exclusively higher in males than in females each year during the 20 years of follow up period in the groups of the 40's, 50's and 60's. In the group of the 40's in males, the prevalence of moderately high blood pressure (160-184 mmHg) increased from 6.3 % in 1971 to 10.6 % in 1977 followed by gradual and consistent depletion to 4.6 % in 1986, and thereafter the depletion turned to a plateau of 4.5 % in 1989. Among the groups of

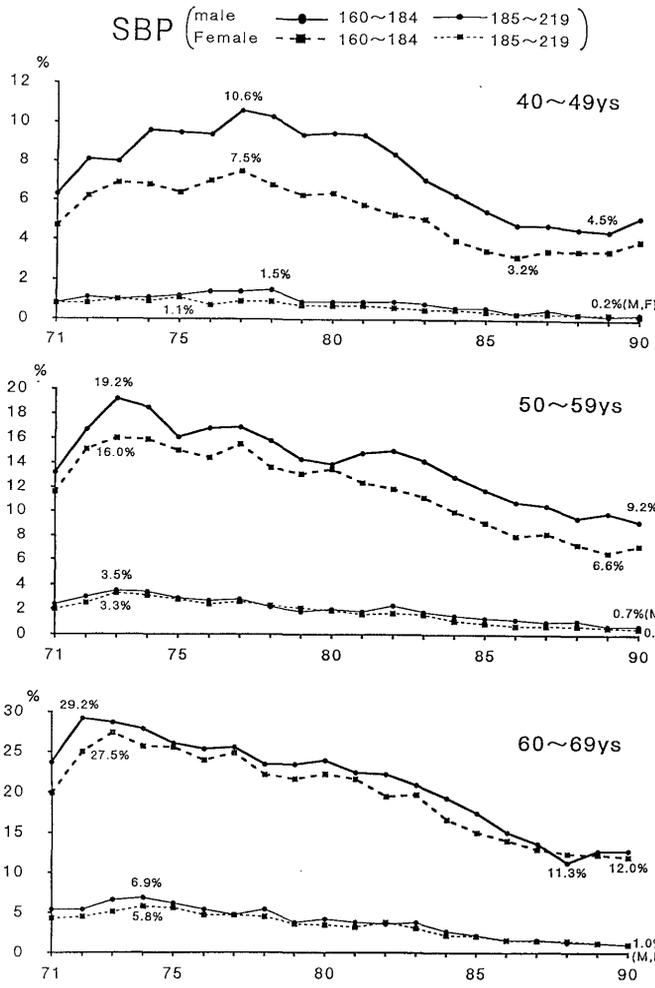


Fig. 4-a Prevalence of systolic hypertension

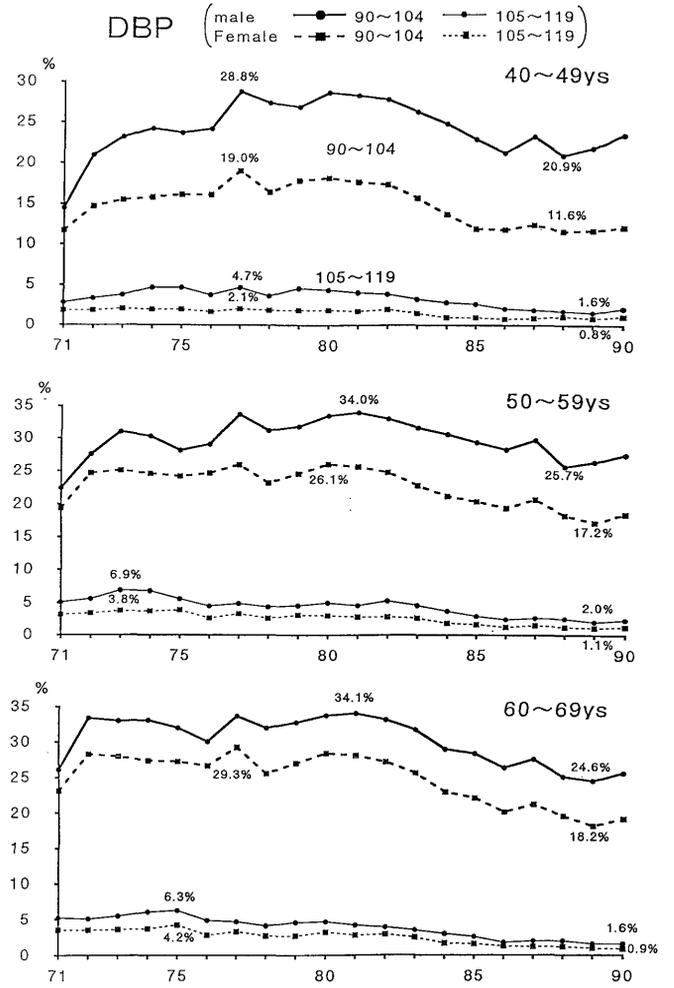


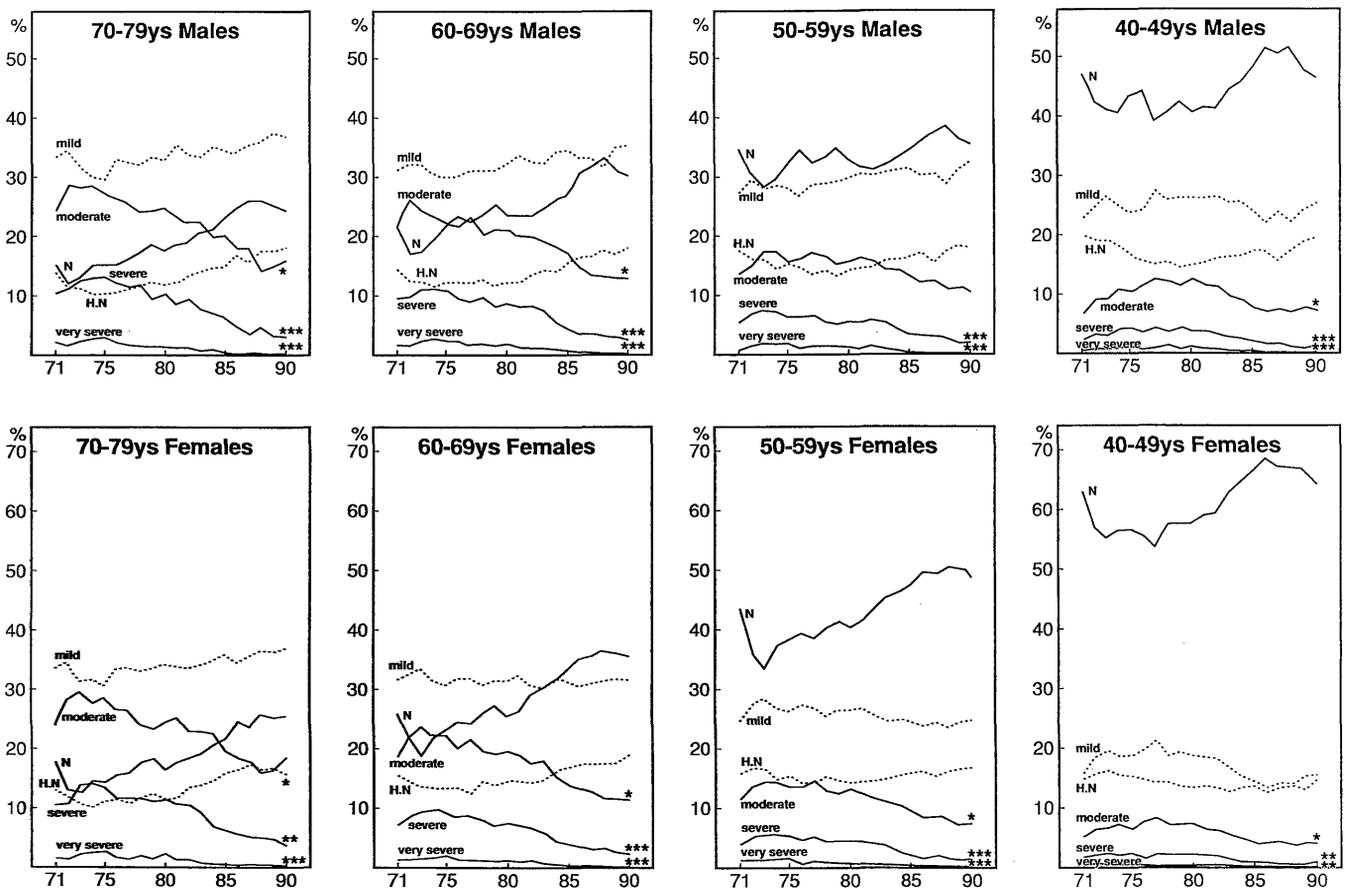
Fig. 4-b Prevalence of diastolic hypertension

Table 1. Annual change in number of cohort

Year	Survivors	New regist	Deaths	Emigrants
1971	78,323	3,628	1,039	1,823
1972	79,123	2,623	1,084	1,410
1973	79,287	2,455	1,070	1,148
1974	79,578	4,131	1,186	1,566
1975	81,196	2,946	1,173	1,848
1976	78,358	3,593	1,166	1,192
1977	79,553	1,256	1,133	1,127
1978	78,537	1,297	1,140	1,480
1979	77,202	1,304	1,184	1,269
1980	76,043	1,188	1,172	1,095
1981	74,956	1,162	1,225	1,276
1982	73,608	912	1,267	856
1983	72,390	1,008	1,192	764
1984	71,437	1,087	1,152	914
1985	70,456	1,063	1,217	933
1986	69,364	847	1,120	960
1987	68,130	826	1,203	715
1988	67,033	623	1,209	723
1989	65,721	523	1,220	589
1990	64,434	521	1,212	577
1991	63,165	563	1,250	568

Table 2 Classification of blood pressure in adults aged 18 years and older

Classification of Blood Pressure for Adults Aged 18 Years and Older		
Category	Systolic, mm Hg	Diastolic, mm Hg
Normal	< 130	< 85
High normal	130-139	85-89
Hypertension		
Stage 1 (mild)	140-159	90-99
Stage 2 (moderate)	160-179	100-109
Stage 3 (severe)	180-209	110-119
Stage 4 (very severe)	≥ 210	≥ 120

**Fig. 5** Prevalence trends of blood pressure at each stage according to the classification by JNC5

- ★ decrease below a half of the maximum prevalence
- ★★ decrease below one-third of the maximum prevalence
- ★★★ decrease below one-quarter of the maximum prevalence

the 50's and 60's, the prevalence gradually decreased throughout the study period except in the initial few years. In females, the same tendency was observed. In summary, the annual prevalence of high systolic blood pressure decreased year by year during the past 10 to 15 years and now it is about a half compared to the maximum value in the group of the 40's and even less than a half in the 50's and 60's in both sexes. The trend of prevalence of high DBP

was also shown demonstrating a similar pattern to SBP although the magnitude of depletion was smaller (Fig. 4-b).

Moreover, the subjects were categorized into 6 groups according to the classification of blood pressure for adults by the 5th report of the Joint National Committee (JNC 5) shown in Table 2.⁹⁾ The trends of prevalence for each group by age and sex are demonstrated in Figs. 5 and

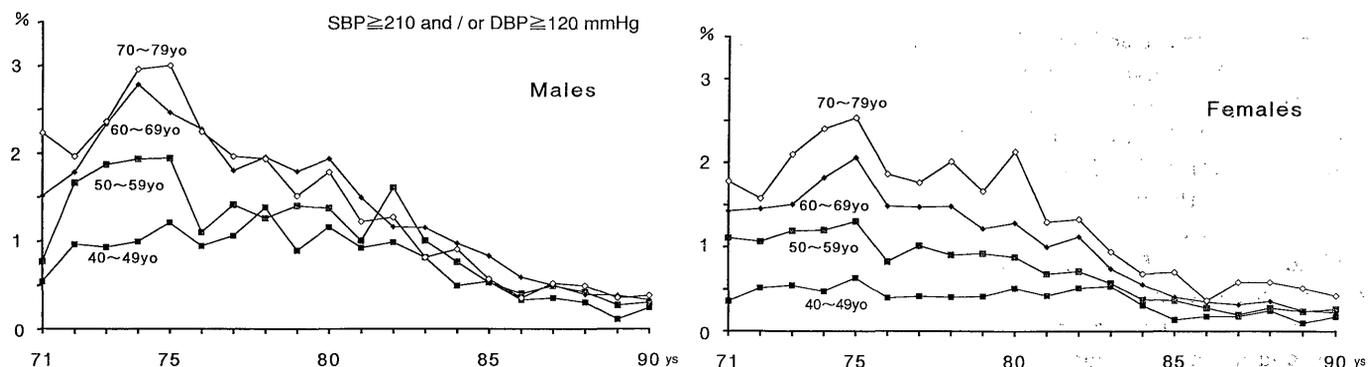


Fig. 6 Prevalence trends of very severe hypertension (stage 4)

6. The prevalence of moderate (stage 2, SBP 160-179 and/or DBP 100-109), severe (stage 3, SBP 180-209 and/or DBP 110-119) and very severe hypertension (stage 4, SBP \geq 210 and/or DBP \geq 120) appears to be declining over a period of the past 15 to 20 years in all age groups in both sexes. For example, the prevalence of moderate hypertension in males in the 70's was 28 % in 1972 and decreased to 12 % in 1988. The decrease to the level approximately a half of the maximum prevalence is indicated by the mark^{*}, to below one-third by^{**} and to below one quarter by^{***}. The most striking depletion was shown in the very severe hypertension groups. The proportion decreased to the level below 0.5 % in the year 1990 in all age groups of both sexes. The decrease in males in the 70's, for example, was from 3 % in 1975 to 0.38 % in 1989. In contrast, the rate of normal pressure groups apparently increased with small fluctuation in all trends by age and sex. For example, it increased from 12 % in 1972 to 26 % in 1987 in males in the 70's and 55 % in 1974 to 68 % in 1987 in females in the 40's. As indicated by dotted line, the rate of high normal and mild hypertension groups showed sustained increment in older age groups but the prevalence plateaued or even declined in the groups of the 40's and 50's.

Discussion

In this report, the annual changes in blood pressure and prevalence of hypertension in registered atomic bomb survivors in Nagasaki during the period from 1971 to 1991 are demonstrated. As shown in the previous studies in Western countries,^{7,10} the progressive increase in SBP with age was also evident in our study. The reason for this phenomenon, at least in part, is widely recognized as aging sclerotic process of the aorta. In another part, it may reflect a cumulative dose of environmental factors interacting over a long period with hereditary susceptibility.¹¹ Contrary to systolic blood pressure, there was revealed no consistent age dependent elevation of diastolic blood

pressure levels. Although the reason remains to be elucidated, we are inclined to attribute it partially to the deaths of more persons in advanced age groups with high diastolic pressure because of the high mortality rate of stroke and cardiovascular disease.

Epidemiologic investigations have indicated that the prevalence of hypertension has decreased and mean systolic and/or diastolic blood pressure has revealed downward trend.^{7,12} In our results, the decline in the mean systolic pressure in the latter 10 years compared to the initial 10 years was evident. The mean systolic blood pressure and the prevalence rate of hypertension in every age group started to decrease during 1973 to 1977 and continued thereafter to decrease slowly but steadily in both sexes, although the magnitude of decline was small after 1986. A remarkable depletion in the prevalence of moderate hypertension (stage 2), severe hypertension (stage 3) and very severe hypertension (stage 4) as classified by JNC-5 was apparent. Especially, the fact that the proportion of the group of stage 4 (SBP \geq 210 mmHg and/or DBP \geq 120 mmHg) remarkably decreased to the level below 0.5 % in 1990 in all age groups of both sexes is much to be emphasized. From these results, the changes in blood pressure levels and prevalence of hypertension are in the preferable direction during the past 15 years in Nagasaki atomic bomb survivors. There are several reports to reveal that the proportion of controlled hypertension has increased.³ Kannel WB et al reported that untreated blood pressure levels in normotensive subjects are not changing over time, that is, only a 1 mmHg decline in mean systolic and diastolic pressure over each 10 year interval was noted.¹⁶ Accordingly, it is reasonable to assume the major factors of the decreased mean systolic and diastolic blood pressure and the downward trend of prevalence rate of hypertension in atomic bomb survivors might be (1) the recent more prevalent antihypertensive treatment, (2) prescription of more effective antihypertensive drugs by practicing physicians, and (3) the life style modification such as weight reduction, salt restriction and high physical

activity.

The downward trend of blood pressure in Nagasaki atomic bomb survivors seems to be even more apparent than that in the general population of Japan that was reported in National Nutrition Survey conducted by Nutrition Section, Ministry of Health and Welfare.⁶⁾ We speculate that the more favorable downward trends in our subjects might be attributed in part to the awakening of individual persons for health and to having more economical advantage to receive medication.

Stroke mortality has been declining remarkably since 1965, and a similar tendency in mortality from ischemic heart disease has been observed since 1970 in Japan.^{13) 14)} A decline in mortality of atomic bomb survivors has been documented by Okajima and Nakamura as "(1) the age-specific death rates by all causes of atomic bomb survivors are lower than those of the controls, and (2) the age-specific death rates by cerebrovascular disease are lower in atomic bomb survivors than in the controls. The latter was subsequently confirmed by Kunihara et al in Hiroshima data.^{15) 17)}

In conclusion, the favorable blood pressure trends in a large population of atomic bomb survivors shown in our study might suggest an important impact. The spread of medical treatment for hypertension has resulted in not only the decreased population with hypertension but also improved severity of disease, which might contribute to the recent improved mortality from stroke and cardiovascular disease. From these results, we believe that more vigorous efforts for treatment and education of the hypertensive persons should be continued.

Acknowledgments

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