Blood Pressure and Performance on the Mini-Mental State Examination in the Very Old

Cross-sectional and Longitudinal Data from the Kungsholmen Project

Zhenchao Guo, Laura Fratiglioni, Bengt Winblad, and Matti Viitanen

The authors examined the association of blood pressure with cognitive function as assessed by the Mini-Mental State Examination (MMSE) in a community-based Swedish cohort of 1,736 people aged 75-101 years. Age, sex, education, antihypertensive medication use, heart disease, and stroke were considered as covariates. Multiple linear regression analysis indicated that both systolic and diastolic blood pressure, measured in 1987-1989, were positively and significantly related to baseline MMSE score; baseline systolic pressure was also positively and significantly related to follow-up MMSE score, measured after an average period of 40.5 months among subjects who were not taking antihypertensive medication at baseline. Furthermore, in the nontreated group, multiple logistic regression showed that individuals with a baseline systolic pressure less than 130 mmHg had an odds ratio of 1.88 (p = 0.05) for follow-up cognitive impairment (MMSE score <24) compared with those whose systolic pressure was 130–159 mmHg. An increased but not statistically significant risk of cognitive impairment was associated with high blood pressure (systolic pressure ≥180 mmHg or diastolic pressure ≥95 mmHg) only in persons taking antihypertensive medication at baseline. Subjects with systolic pressure of 160–179 mmHg tended to be at lower risk of cognitive impairment. These results may support the view that a certain blood pressure level, particularly a systolic pressure of at least 130 mmHg, is important to the maintenance of cognitive functioning in the very old. They also suggest that severe hypertension that is not well controlled (systolic pressure ≥180 mmHg or diastolic pressure ≥95 mmHg) is still a threat to cognitive function in this age group. However, the use of blood pressure measurements made at a single visit and the relatively short follow-up period should be considered when interpreting these results.


Aged; antihypertensive agents; blood pressure; cardiovascular diseases; cognition

An issue of growing interest is the association between blood pressure and cognitive decline in the absence of clinically recognized stroke. Many clinical studies have shown that hypertensive subjects perform more poorly than normotensive subjects in one or several areas of cognitive tasks (1-11), but a few studies have failed to find this association (12-14). Several epidemiologic studies have tried to clarify the issue by investigating the relation between blood pressure and cognitive performance in the general elderly population. Two reports from the Framingham Study observed an inverse relation (15, 16), leading to the conclusion that elevated blood pressure may be related to a modest decline in cognitive functioning (15). Wallace et al. (17) found that diastolic (but not systolic) hypertension was significantly related to lower performance on a memory test. In contrast, Scherr et al. (18) reported that neither systolic nor diastolic blood pressure was related to cognitive performance in the elderly. Few studies in this field have focused specifically on the very old. When the sample from the Framingham Study was stratified by age in another report, Farmer et al. (19) observed that the cognitive performance of people aged 75 years or older was better on several selected tests if they had either isolated systolic or diastolic hypertension, although the association was no longer significant after adjustment for other variables. A recent report from the Honolulu-Asia Aging Study found that systolic blood pressure less than 110 mmHg was cross-sectionally related to poor cognitive function in men aged 74–93 years, although increased midlife systolic pressure was a significant predictor of...
reduced cognitive function in late life in this cohort (20). These results imply that the relation between blood pressure and cognitive performance in the very old may differ from that observed in other age groups.

In this study, we examined the relation of baseline blood pressure to baseline and follow-up cognitive function in a geographically defined population with a baseline age of 75 years or more.

MATERIALS AND METHODS

Study population

The Kungsholmen Project is a longitudinal study of aging and dementia (21). The population base included all inhabitants of the Kungsholmen district of Stockholm, Sweden, who were aged 75 years or older on October 1, 1987. Of the eligible subjects, 1,736 (74 percent) completed both blood pressure recording and cognitive testing at baseline. Of 1,736 baseline participants, 1,022 (59 percent) individuals were retested after an average follow-up period of 40.5 months (standard deviation (SD), 7.0). The baseline survey was completed in April 1989. Follow-up cognitive testing began in November 1990 and ended in December 1992. The cognitive test was administered using the same procedures at baseline and follow-up.

Measurements

Cognitive function was assessed by means of the Mini-Mental State Examination (MMSE) (22), which had been directly translated into Swedish with no major modifications. The MMSE is a screening test for dementia, and it is also frequently used to evaluate cognitive impairment in epidemiologic studies (23–26). It measures several domains of cognitive function, yielding a possible total score ranging from 0 (worst) to 30 (best) points. Both serial subtraction of 7’s and backwards spelling of the word “konst” (the Swedish word for art) are included in the Swedish version of the MMSE, but only the higher score from these two test domains was used for analysis.

Arterial blood pressure was measured with a mercury sphygmomanometer with the subject sitting after having rested for 5 minutes. Systolic and diastolic pressure were defined as Korotkoff phases 1 and 5, respectively. If the first reading was abnormal, two additional readings were taken, and the mean of the second and third readings was used for analysis. Although the cognitive testing and blood pressure measurement were usually conducted by the same nurse at baseline, neither nurses nor participants were aware that blood pressure would subsequently be related to cognitive performance.

Information on drug use was collected for the 2 weeks preceding the baseline interview. Participants were asked about use of both prescription and nonprescription drugs, and drug containers or prescription forms were inspected to verify the information provided. If medications were administered by caregivers or health care personnel, these persons were asked about the participant’s drug use. Antihypertensive drugs included all medicines potentially used for lowering blood pressure, such as diuretics, β-blockers, calcium channel antagonists, α-blockers, and angiotensin-convert enzyme inhibitors (Anatomic-Therapeutic-Chemical (ATC) classification system (27) codes C02, C03, and C07). For 10 percent of the subjects, data on drug use and education were obtained from a proxy informant (relative, caregiver, or other). Most baseline participants (80 percent) were examined at the research center.

Information on medical history for all subjects was collected from the computerized inpatient registry system, which was started in 1969 and covers all hospitals in the Stockholm area. Coronary heart disease (International Classification of Diseases, Eighth Revision (ICD-8) (28), codes 410–414), cardiac dysrhythmia (ICD-8 code 427), heart failure and other heart diseases (ICD-8 codes 428, 390–405, 415–426, and 429), and stroke (ICD-8 codes 430–438) were included in the analyses as covariates.

Statistical analyses

A multiple linear regression model was used to examine the association between blood pressure and MMSE score, where MMSE score was the dependent variable and blood pressure was the independent variable. Baseline and follow-up MMSE score were analyzed separately with baseline blood pressure. In analyses of the total population, systolic and diastolic pressure were separately entered into the model with all of the covariates (age, sex, education, antihypertensive medication use, heart disease, and stroke). Analyses were also conducted in several subpopulations characterized by antihypertensive medication use, age, sex, or cardiovascular disease. The regression coefficient for blood pressure was expressed as the mean change in MMSE score for every 10-mmHg increase in blood pressure. The distribution of MMSE scores was skewed toward high values. However, no data transformations, including logarithmic transformation of MMSE scores, substantially improved the linearity or strength of the association between blood pressure and MMSE score. Thus, results from the models based on the actual MMSE scores are presented here.
A multiple logistic regression model was used to calculate odds ratios for cognitive impairment, defined as an MMSE score less than 24. Age was included as a continuous variable in all models. Coronary heart disease, cardiac dysrhythmia, and heart failure and other heart diseases were combined into one variable because their data overlapped to a large extent. There were two people with less than 4 years of education in this population. A significant difference in MMSE score was found only between persons with <8 years of education and those with ≥8 years of education. Therefore, education was treated as a dichotomous variable (<8 vs. ≥8 years). As expected, results were the same regardless of whether education was included in the models as a continuous or a categorical variable. All analyses were conducted with SPSS statistical software (SPSS, Inc., Chicago, Illinois).

RESULTS

Table 1 shows numbers of subjects, mean MMSE scores, and the prevalence of MMSE scores less than 24 according to various factors in the baseline population, according to blood pressure level and all covariates: The Kungsholmen Project, Stockholm, Sweden, 1987-1989.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total population</th>
<th>No use of antihypertensive medication</th>
<th>Use of antihypertensive medication</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of subjects</td>
<td>Mean MMSE score</td>
<td>% with MMSE score &lt;24</td>
</tr>
<tr>
<td>Total</td>
<td>1,736</td>
<td>24.8</td>
<td>20.0</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75-79</td>
<td>669</td>
<td>26.4</td>
<td>10.9</td>
</tr>
<tr>
<td>80-84</td>
<td>549</td>
<td>25.3</td>
<td>17.1</td>
</tr>
<tr>
<td>85-101</td>
<td>518</td>
<td>22.4</td>
<td>34.9</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
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<tr>
<td>Male</td>
<td>418</td>
<td>25.5</td>
<td>17.0</td>
</tr>
<tr>
<td>Female</td>
<td>1,318</td>
<td>24.6</td>
<td>21.0</td>
</tr>
<tr>
<td>Education (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;8†</td>
<td>927</td>
<td>24.0</td>
<td>25.7</td>
</tr>
<tr>
<td>8-10</td>
<td>469</td>
<td>25.9</td>
<td>13.0</td>
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<tr>
<td>&gt;10</td>
<td>340</td>
<td>25.8</td>
<td>14.4</td>
</tr>
<tr>
<td>Coronary heart disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1,577</td>
<td>25.0</td>
<td>18.9</td>
</tr>
<tr>
<td>Yes</td>
<td>159</td>
<td>23.1</td>
<td>31.4</td>
</tr>
<tr>
<td>Cardiac dysrhythmia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1,559</td>
<td>25.1</td>
<td>18.7</td>
</tr>
<tr>
<td>Yes</td>
<td>177</td>
<td>23.0</td>
<td>32.2</td>
</tr>
<tr>
<td>Heart failure and other heart diseases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1,597</td>
<td>25.1</td>
<td>18.3</td>
</tr>
<tr>
<td>Yes</td>
<td>139</td>
<td>21.5</td>
<td>40.3</td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1,591</td>
<td>25.2</td>
<td>18.1</td>
</tr>
<tr>
<td>Yes</td>
<td>145</td>
<td>21.2</td>
<td>41.4</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;130</td>
<td>198</td>
<td>21.3</td>
<td>41.9</td>
</tr>
<tr>
<td>130-159</td>
<td>738</td>
<td>25.0</td>
<td>20.1</td>
</tr>
<tr>
<td>160-179</td>
<td>493</td>
<td>25.4</td>
<td>15.8</td>
</tr>
<tr>
<td>≥180</td>
<td>307</td>
<td>26.0</td>
<td>12.7</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;75</td>
<td>400</td>
<td>23.3</td>
<td>29.5</td>
</tr>
<tr>
<td>75-94</td>
<td>1,094</td>
<td>25.2</td>
<td>17.6</td>
</tr>
<tr>
<td>≥95</td>
<td>242</td>
<td>25.9</td>
<td>15.7</td>
</tr>
</tbody>
</table>

* MMSE, Mini-Mental State Examination (22).† Two persons had less than 4 years of education.
People with low blood pressure (systolic pressure <130 or diastolic pressure <75 mmHg) had a lower mean MMSE score and a higher prevalence of MMSE scores under 24 than those with higher blood pressure. The group of people taking antihypertensive medication had a higher mean MMSE score and higher proportions of subjects with heart disease (coronary heart disease, cardiac dysrhythmia, and heart failure and other heart diseases) than the group of persons who were not taking antihypertensive medication.

Table 2 lists the multiple linear regression coefficients for the relation between MMSE score and each independent variable in the baseline population. In any group, both systolic and diastolic blood pressure were positively and significantly related to MMSE score. For example, every 10-mmHg increase in systolic pressure was associated with a 0.49-unit increase in MMSE score in the group not taking antihypertensive medication. Overall, systolic pressure in combination with all of the covariates explained 20 percent of the MMSE score variance. Use of antihypertensive medication was correlated with a 1.66-unit increase in MMSE score, and it reduced in varying amounts the association of all other variables with MMSE score.

Blood pressure was inversely correlated with age in the baseline population. Pearson correlation coefficients were −0.09 (p < 0.01) for systolic pressure and −0.19 (p < 0.01) for diastolic pressure. For additional control for the potential effect of age on the relation between blood pressure and cognitive performance, we stratified the baseline total population into three groups according to age (table 3). The regression coefficient for systolic pressure, adjusted for all of the covariates, including age as a continuous variable, was significant in all three age groups, while the significant regression coefficient for diastolic pressure emerged only in the oldest age group. Table 3 also lists the regression coefficients for the relation between baseline blood pressure and baseline MMSE score in sub-populations characterized by sex or cardiovascular disease. The positive association of systolic pressure with MMSE score was consistently significant in all subpopulations, but the regression coefficient for diastolic pressure was not significant in men.

A total of 1,022 baseline individuals participated in follow-up cognitive testing. Of the 714 nonrespondents, 423 (59.2 percent) had died and 31 (4.3 percent) had moved during the follow-up period, while 260 (36.4 percent) refused to participate. People aged ≥85 years at baseline had higher mortality than those aged <85 years (35.1 percent vs. 17.7 percent). Although the follow-up and baseline populations had similar mean MMSE scores (24.6 (SD, 5.6) vs. 24.8 (SD, 5.8)), the proportion with an MMSE score less than 24 was higher in the follow-up population than in the baseline population (25.4 percent vs. 20.0 percent).

Table 4 gives the multiple linear regression coefficients for the relation between baseline blood pressure and follow-up MMSE score. Baseline systolic pressure was positively related to follow-up MMSE score in the total population and in persons not taking antihypertensive medication at baseline. The regression coefficient for baseline diastolic pressure was not significant. Use of antihypertensive medication at baseline was associated with a higher follow-up MMSE score (regression coefficient = 1.19, p = 0.0004). Similar results were obtained in persons who had not had cardiovascular disease before follow-up testing.

TABLE 2. Regression coefficients (β) for baseline MMSE* score in relation to baseline blood pressure and all covariates: The Kungsholmen Project, Stockholm, Sweden, 1987–1989†

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total population</th>
<th>No use of antihypertensive medication</th>
<th>Use of antihypertensive medication</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>SE*</td>
<td>p value</td>
</tr>
<tr>
<td>Age (years)</td>
<td>-0.29</td>
<td>0.03</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Female sex</td>
<td>-0.79</td>
<td>0.30</td>
<td>0.008</td>
</tr>
<tr>
<td>&lt;8 years of education (vs. ≥8 years)</td>
<td>-1.57</td>
<td>0.25</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Heart disease‡</td>
<td>-2.10</td>
<td>0.33</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Stroke</td>
<td>-2.97</td>
<td>0.46</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Systolic blood pressure§</td>
<td>0.41</td>
<td>0.06</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Diastolic blood pressure§</td>
<td>0.45</td>
<td>0.11</td>
<td>0.0001</td>
</tr>
<tr>
<td>Use of antihypertensive medication</td>
<td>1.66</td>
<td>0.26</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

* MMSE, Mini-Mental State Examination; SE, standard error.
† Systolic and diastolic pressure were entered separately into a multiple linear regression model with all covariates; the coefficient of each covariate was derived from the model which included all covariates and systolic blood pressure.
‡ Included coronary heart disease, cardiac dysrhythmia, and heart failure and other heart diseases.
§ Change per 10-mmHg increase.
Table 3 shows the odds ratios for follow-up cognitive impairment (MMSE score <24) from multiple logistic regression analysis. There was a linear trend in terms of a decreasing odds ratio for cognitive impairment according to increasing baseline systolic blood pressure among persons who were not taking antihypertensive medication at baseline (trend test: p = 0.03). This trend was largely due to the elevated odds ratio associated with a systolic pressure less than 130 mmHg (p = 0.05). High baseline blood pressure (systolic pressure ≥180 mmHg or diastolic pressure ≥95 mmHg) was related to an elevated odds ratio in persons taking antihypertensive medication at baseline, although the relation was not significant. Subjects with systolic pressures of 160–179 mmHg tended to be at lower risk of cognitive impairment.

To determine the risk of developing cognitive impairment, we excluded from the follow-up population those who had had an MMSE score less than 24 at baseline. There was no significant relation between low or high blood pressure and the risk of developing cognitive impairment among persons taking (n = 373) or not taking antihypertensive medication at baseline. However, antihypertensive medication use at baseline was found to be related to a significantly decreased risk of developing cognitive impairment (adjusted odds ratio = 0.62, 95 percent confidence interval 0.42–0.93).

DISCUSSION

In this community-based population of very old adults, we examined the relation between blood pressure and cognitive function as assessed by the MMSE. In the baseline population, blood pressure (both systolic and diastolic) was strongly and positively related to MMSE score. The relation emerged even in persons taking antihypertensive medication at baseline. However, antihypertensive medication use at baseline was found to be related to a significantly decreased risk of developing cognitive impairment (adjusted odds ratio = 0.62, 95 percent confidence interval 0.42–0.93).
Baseline blood pressure (mmHg)  | No use of antihypertensive medication at baseline | Use of antihypertensive medication at baseline
---|---|---
**Systolic pressure**
Model 1§ | OR† | 95% CI† | OR | 95% CI
<130 | 0.89 | 0.81-0.97 | 1.08 | 0.97-1.20
130-159¶ | 1.88 | 1.00-3.52 | 0.87 | 0.29-2.65
160-179 | 0.85 | 0.51-1.41 | 0.78 | 0.43-1.41
≥180 | 0.78 | 0.43-1.39 | 1.62 | 0.88-2.98
**Diastolic pressure**
Model 1§ | OR† | 95% CI† | OR | 95% CI
<75 | 0.89 | 0.74-1.08 | 1.15 | 0.92-1.43
75-94¶ | 0.91 | 0.54-1.52 | 0.96 | 0.52-1.79
≥95 | 0.65 | 0.35-1.20 | 1.43 | 0.73-2.82

* Defined as a Mini-Mental State Examination (22) score less than 24.
† Systolic and diastolic pressure were analyzed separately in multiple logistic regression models adjusted for age, sex, education, heart disease, and stroke.
‡ OR, odds ratio; CI, confidence interval.
§ Blood pressure was entered as a continuous variable (change per 10-mmHg increase).
¶ Reference category.

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TABLE 5. Odds ratios relating baseline blood pressure to follow-up cognitive impairment*: The Kungsholmen Project, Stockholm, Sweden, 1987–1992†

Baseline blood pressure (mmHg)

line systolic pressure was positively related to follow-up MMSE score measured after an average period of 40.5 months.

Compared with a medium level of systolic blood pressure (130–159 mmHg), low systolic pressure (<130 mmHg) was related to an elevated odds ratio (p = 0.05) for follow-up cognitive impairment (MMSE score <24) in persons who were not taking antihypertensive medication at baseline, and systolic pressures of 160–179 mmHg tended to be related to a decreased odds ratio for follow-up cognitive impairment. However, systolic pressure ≥180 mmHg or diastolic pressure ≥95 mmHg was related to an increased odds ratio for follow-up cognitive impairment (although the relation was not statistically significant) in persons taking antihypertensive medication at baseline.

Our finding of a positive relation between blood pressure and MMSE score above the age of 75 years is in agreement with unpublished data from the Rotterdam Study, where similar results from linear regression analyses were obtained (29). A recent report from the Honolulu-Asia Aging Study found that systolic pressure less than 110 mmHg was cross-sectionally related to poor cognitive function in men aged 74–93 years. These results are, to some degree, in accordance with the clinical observation that Alzheimer's disease patients have lower arterial blood pressures than nondemented individuals (30, 31). Our previous study also observed that dementia patients had lower blood pressures in this cohort (32).

Based on the observation that low blood pressure increases the short-term risk of mortality but predicts better long-term survival, it has been suggested that elderly persons with low blood pressure may be a mixture of two subgroups: people with low blood pressure due to multiple chronic diseases and people with low blood pressure who are in good health (33). This hypothesis may explain our finding of an attenuated association between low blood pressure and follow-up cognitive impairment. Similarly, the relation of low blood pressure to poor cognitive function has been attributed to the presence of some diseases which may be responsible for both the blood pressure reduction and cognitive decline (20). However, adjustment for hospitalization for heart disease and stroke did not significantly modify the relation in this study.

Our results concerning mildly elevated systolic blood pressure (160–179 mmHg), which was found to be no longer harmful to cognitive function in the very old, do not diminish the importance of the findings that elevated midlife blood pressure may predict poorer late-life cognitive function (15, 20, 34), since our data also suggest that severe hypertension that is not well controlled (systolic pressure ≥180 mmHg or diastolic pressure ≥95 mmHg) is still harmful in this age group. There is no doubt that hypertension should be treated in middle-aged persons.

We found that antihypertensive medication use at baseline was related to a 40 percent decreased risk of developing cognitive impairment. The possible mechanism might be that antihypertensive medications re-
duce the risk of cognitive impairment by lowering the incidence of clinically unrecognized cardiovascular disease. However, it is also possible that some mildly hypertensive persons who are free of severe complications, such as cerebral lesions, may have a lower risk of cognitive impairment.

Several possible limitations of our study should be considered. First, recording of blood pressure at a single visit may diminish the accuracy of the data (35, 36). Such imprecision in blood pressure measurement would bias the relation towards the null. This limitation may at least partially contribute to the weak relation found between diastolic pressure and follow-up MMSE score. However, it is possible that systolic pressure has a stronger association with cognitive function than diastolic pressure (20). Particularly, such misclassification may reduce the power to detect the difference in follow-up MMSE score between those with systolic pressure of 130–159 mmHg and those with systolic pressure of 160–179 mmHg.

Second, the MMSE is a brief cognitive test which may not detect subtle cognitive changes. However, the MMSE is frequently used as a research instrument in epidemiologic studies (24–26), and it has been well validated as a screening test for dementia (23). In this population, at the cutoff point of an MMSE score less than 24, the estimated sensitivity for dementia was 87 percent and the specificity was 92 percent (37).

A third limitation is that the data on cardiovascular disease were collected from the computerized inpatient register system, which would identify the more severely ill and miss mild cases of illness. To determine the effect this might have had on our results, we selected a sample of 624 persons from the baseline population and conducted analyses using cardiovascular disease data from the interview with the subject or proxy. The results pertaining to the association of MMSE score with blood pressure and stroke were similar to those derived from the entire baseline population using the data from the register system, but the association with heart disease was markedly reduced (regression coefficient = —0.58, p = 0.38). This result could reflect the inaccuracy of recall data in older people; but more likely, in our opinion, it suggests that mild heart disease is unrelated to cognitive function. This conclusion was supported by further analysis showing that use of cardiac glycosides, which probably reflects the presence of heart failure, was not significantly related to baseline and follow-up MMSE scores, and it did not modify the relation between blood pressure and cognitive performance (data not shown).

The fourth limitation of this study is that we did not obtain detailed information on other potentially confounding factors, such as smoking, alcohol intake, and occupation. However, there is no reason to believe that smoking and alcohol use would substantially bias our results, in light of the uncertain effect of smoking on cognitive function (9, 25) and the low rate of alcohol abuse in Sweden (38).

Finally, our analyses failed to show that baseline low systolic blood pressure may significantly increase the risk of developing cognitive impairment. Unfortunately, the limited sample size and the attrition rate make conclusive statements impossible. We cannot determine with certainty the direction of the observed association of low systolic pressure with cognitive impairment.

In conclusion, it seems that the relation between blood pressure and cognitive function is more complicated in the very old than in other age groups. The results of this study show that untreated systolic pressure is positively related to cognitive performance above the age of 75 years, and they particularly emphasize the relation of low blood pressure to poor cognitive function. Our data may support the view that a certain level of blood pressure, particularly a systolic pressure of at least 130 mmHg, is necessary to maintain cerebral perfusion and thereby to preserve cognitive ability (39), especially for those aged 75 years or more. However, our data also suggest that severe hypertension that is not well controlled (systolic pressure ≥180 mmHg or diastolic pressure ≥95 mmHg) is still a threat to cognitive function in this age group. Multidisciplinary studies are needed to clarify the causal relation between blood pressure and cognitive function, and cognitive function should be taken into account in further evaluations of blood pressure's impact on mortality and other health outcomes in the very old.

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