Association of Dental Status With Blood Pressure and Heart Rate in 80-Year-old Japanese Subjects

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SUMMARY

Periodontal disease is one of the main reasons for the loss of teeth in elderly subjects, and it has been reported that periodontal disease is a potential risk factor for cardiovascular disease. However, little data is available regarding the association between dental status and blood pressure or heart rate in elderly individuals, particularly in subjects over 80 years old. We studied the cross-sectional association between dental status and blood pressure or heart rate in 499 Japanese (195 men and 304 women) who were 80 years old. The subjects were divided into 4 groups according to the number of original teeth; ie, edentulous (n = 176), 1 to 9 teeth (n = 141), 10 to 19 teeth (n = 109), and more than 20 teeth (n = 73). Mean systolic and diastolic blood pressures did not differ among the groups. However, heart rate decreased from 71.6 and 72.2 /min in the edentulous and 1 to 9 teeth groups, respectively, to 67.3 and 67.4 /min in the 10 to 19 teeth and more than 20 teeth groups, respectively (test for trend, P = 0.0008). In multiple regression analysis, the inverse association between the number of teeth and heart rate was statistically significant independently of other confounding factors. These results are the first to show a close inverse relationship between the number of teeth and heart rate in octogenarians, although the underlying mechanisms have not been determined. (Jpn Heart J 2003; 44: 943-951)

Key words: 80 year-olds, Japanese, Teeth

ALTERATIONS in intracellular and extracellular calcium concentrations have been hypothesized to be involved in the pathogenesis of hypertension.1) Compared with normotensive controls matched for age, sex, and race, hypertensive subjects have been reported to show a significant reduction in ionized calcium concentrations.2) Furthermore, some epidemiological studies have revealed an inverse association between calcium intake and blood pressure.3,4) On the other hand, although associations have been shown between calcium intake and dental

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status or bone mineral density, associations between cardiovascular variables (blood pressure and heart rate) and dental status or bone mineral density have not yet been determined.

The number of original teeth and bone mineral density decrease with age. The 8020 Data Bank Survey, a cross-sectional survey conducted in Japan, was a study designed to explore the relationship between the systemic and dental health conditions of very elderly subjects. The participants in our study were all 80 years old; thus, we did not consider the effect of age on the changes in blood pressure, heart rate, and bone mineral density. Periodontal disease is one of the main reasons for the loss of teeth in elderly subjects, and it has been reported that periodontal disease is a potential risk factor for cardiovascular disease. Therefore, we hypothesized that some association is found between dental status and the cardiovascular variables, such as blood pressure and heart rate. We have evaluated the association between dental status and blood pressure or heart rate in the subjects participating in the 8020 Data Bank Survey. In addition, the association between blood pressure and bone mineral density was also determined. Since epidemiological examinations have shown that quantitative ultrasound moderately correlates with bone mineral density, in the present study we elected to estimate bone mineral density by parameters measured by ultrasound.

METHODS

Study population: This study is part of a community-based cross-sectional survey of the 8020 Data Bank Survey, which was conducted in Japan. The 8020 Data Bank Survey was designed to collect baseline data on the systemic and dental health conditions in 80-year-old subjects and to promote the idea that everyone should still have at least 20 original teeth by the age of 80. All participants were born in 1917, and thus were 80 years old when the survey was conducted. In the present study, we analyzed data from nine districts (Munakata City, Yukuhashi City, Buzen City, Tobata Ward in Kitakyushu City, Katsuyama Town, Toyotsu Town, Tsuiki Town, Kanda Town, and Shinyoshitomi Village) in Fukuoka Prefecture. Among these nine districts, 1244 people were born in 1917, and 499 residents (195 men and 304 women) participated and completed the physical, blood, and bone mineral density examinations performed in this survey. All participants were ambulatory and independent in their daily activities. The details of the study protocol were explained to the subjects, and informed consent was obtained prior to participation.

Data collection: The examination included completion of a medical questionnaire including questions regarding smoking history, physical activity, and alcohol consumption. All subjects except those who lived in two cities (Buzen City
and Yukuhashi City; 130 subjects) were questioned as to any medications they were currently taking. Serum total cholesterol and creatinine concentrations were measured. Serum calcium concentration was measured and was corrected by serum albumin concentration in order to estimate ionized calcium concentration, according to the following formula: Corrected Serum Calcium (mmol/L) = 0.2495 × (4 - Serum Albumin (g/dL)) + Serum Calcium (mmol/L). Height and weight were measured, and body mass index (BMI) was calculated. BMI was defined as weight (in kilograms) divided by height (in meters squared).

The subjects were kept in a sitting position for at least 10 minutes in a quiet room; then sitting blood pressure was measured by an oscillometric method using an automatic device (BP-103, Nippon Colin, Komaki, Japan). Standard 12-lead electrocardiograms were recorded using a paper speed of 25 mm/s, and heart rate was calculated.

Calcaneal ultrasound measurement (Lunar Co., Achilles A-1000PLUS, Madison, WI) was performed using water-based devices on the right calcaneal bone with the subjects in the sitting position. Ultrasound uses high-frequency sound waves to measure the heel bone, using the velocity of the ultrasound signal (speed of sound) and the frequency attenuation (broadband ultrasound attenuation). Speed of sound and broadband ultrasound attenuation are combined to form an index called stiffness, which, according to the manufacturer, is expressed as a percentage of the result from young adults (peak bone mass).

Dental health conditions, including the number of original teeth, were examined by dentists. Physical ability was evaluated by counting the number of hops.

Data Analysis: Subjects were divided into four groups according to the number of original teeth. In order to analyze the association of the number of original teeth with systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate, a one-way ANOVA was performed. In addition, we performed multiple regression analyses separately for SBP, DBP, and heart rate in order to establish their respective association with the number of original teeth. P values < 0.05 were considered statistically significant.

RESULTS

The 8020 Data Bank Survey was designed to collect baseline data of systemic and dental health conditions in 80-year-old subjects and to promote the idea that everyone should still have at least 20 original teeth by the age of 80. In addition, a large number of the participants are edentulous. According to the number of original teeth, therefore, the subjects were divided into 4 groups; ie, edentulous (n = 176), 1 to 9 teeth (n = 141), 10 to 19 teeth (n = 109), and more than 20 teeth (n = 73) (Table I). Table I also shows the mean values (and SE for continuous
variables) of potentially confounding variables in terms of the classes of number of teeth. Habitual alcohol intake was defined as alcohol intake exceeding 3 times per week.

The Figure shows the mean SBP, DBP, and heart rate in terms of the class of number of teeth. Mean SBP and DBP did not differ among the groups; however, heart rate decreased from 71.6 and 72.2 /min in the edentulous and 1 to 9 teeth groups, respectively, to 67.3 and 67.4 /min in 10 to 19 teeth and more than 20 teeth groups, respectively (test for trend, $P = 0.0008$).

Table II shows the results of multiple regression analysis on heart rate in association with number of teeth and other confounding factors, including corrected serum calcium, sex, current smoking status, SBP, BMI, bone stiffness, number of steps, and habitual alcohol intake known to influence heart rate and number of teeth. The number of teeth was independently and inversely associated with heart rate ($P = 0.0012$). Corrected serum calcium concentration was also found to show a significant independent association with heart rate ($P = 0.009$).

In order to evaluate the effect of antihypertensive treatment relative to the results of the present study, subjects who had been taking antihypertensive drugs or whose medications were unknown were excluded, and multiple regression analyses for heart rate were performed again. After these exclusions, 121 men

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number of original teeth</th>
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<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>n</td>
<td>176</td>
</tr>
<tr>
<td>Men/women</td>
<td>62/114</td>
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<tr>
<td>BMI (kg/m$^2$)</td>
<td>22.94 ± 0.27</td>
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<tr>
<td>Corrected serum calcium (mmol/L)</td>
<td>2.18 ± 0.01</td>
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<tr>
<td>Serum total cholesterol (mmol/L)</td>
<td>5.33 ± 0.07</td>
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<tr>
<td>Serum creatinine (µmol/L)</td>
<td>85.54 ± 1.67</td>
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<tr>
<td>Bone stiffness (%)</td>
<td>63.4 ± 0.9</td>
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<tr>
<td>Number of steps</td>
<td>31.1 ± 0.6</td>
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<tr>
<td>Habitual alcohol intake (%)</td>
<td>17.4</td>
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<tr>
<td>Current smoking (%)</td>
<td>11.5</td>
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<tr>
<td>Medications known (n)</td>
<td>129</td>
</tr>
<tr>
<td>Hypertension medications (%)</td>
<td>24.0</td>
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<tr>
<td>Cholesterol medications (%)</td>
<td>8.5</td>
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Values are mean ± SE. n = number of subjects; BMI = body mass index.
and 178 women remained to be studied. Number of teeth was still found to be significantly inversely associated with heart rate ($P = 0.034$).

Associations between bone stiffness and SBP or DBP were determined for each sex because the mean value of bone stiffness was significantly different between men and women (73.0 ± 0.9% and 58.5 ± 0.5%, respectively, $P = 0.0001$). In simple correlation analyses, SBP and DBP were significantly correlated with bone stiffness in men ($r = 0.159$, $P = 0.026$ in SBP and $r = 0.163$, $P = 0.023$ in DBP), but not in women ($r = 0.074$, $P = 0.199$ in SBP and $r = 0.101$, $P = 0.080$ in DBP). Table III presents the results of multiple regression analyses of SBP and DBP in association with bone stiffness and other confounding factors,
including serum creatinine, BMI, number of teeth, corrected serum calcium, current smoking, and habitual alcohol intake known to influence blood pressure and bone stiffness in men. Bone stiffness was independently and significantly associated with DBP ($P = 0.035$), but not with SBP ($P = 0.079$).

**DISCUSSION**

The principal finding of the present study is that the number of teeth is significantly and inversely associated with heart rate in aged individuals in Japan. The advantage of the present study is that the subjects participating in the survey were all 80 years old. Accordingly, the effect of aging on changes in blood pressure and heart rate did not need to be considered. To the best of our knowledge, the present study is the first to demonstrate the existence of a close inverse association between the number of teeth and heart rate in very elderly subjects.
Some previous epidemiological studies have reported a relationship between heart rate and coronary heart disease or cardiovascular death. \(^{14-16}\) The Chicago People Gas Co. Study has found a significant association between resting heart rate and the development of coronary heart disease events during the subsequent 10 years. \(^{17}\) In the NHANES Study, in addition, a heart rate higher than 84 beats/min implied a greater risk of cardiovascular mortality for both sexes, especially for elderly persons. \(^ {18}\) In the present study, a close inverse relationship between heart rate and the number of teeth was present in the elderly, suggesting that the number of teeth may predict cardiovascular morbidity and mortality in elderly subjects.

In the present study, the inverse association between the number of teeth and heart rate was highly statistically significant, independent of corrected serum calcium concentration, sex, current smoking status, systolic blood pressure, BMI, bone stiffness, physical ability assessed by the number of steps, and alcohol intake. The present study, however, did not elucidate the underlying mechanisms that may exist between the number of teeth and heart rate. Periodontal disease is one of the main reasons for the loss of teeth in adults, and it has been reported that periodontal disease is a potential risk factor for coronary heart disease and cerebrovascular disease. \(^ {7-9}\) Therefore, some associations may be present among periodontal disease, the number of teeth, heart rate, and cardiovascular disease morbidity, and mortality in the elderly. Further prospective studies will be needed to determine whether the number of teeth predicts cardiovascular mortality and morbidity in the elderly.

The corrected serum calcium concentration was also found to show a significant independent association with heart rate. Based only on the present study, it seems difficult to account for these results. However, intravenous infusion of calcium gluconate for 3 hours has been reported to increase the plasma epinephrine concentration, suggesting that serum calcium may stimulate the adrenal gland. \(^ {19}\) Although plasma epinephrine concentrations have not been determined in the present study, the serum calcium concentration may be linked to heart rate through its stimulatory effect on the adrenal gland.

The limitation of the present study is that data on medications used were available in 74\% of the studied subjects, and 19\% of the studied subjects were being treated with antihypertensive agents (Table I). In multiple regression analyses, however, heart rate was still found to be significantly inversely associated with the number of teeth after the exclusion of subjects taking antihypertensive drugs and those whose medications were unknown. That is, the data regarding antihypertensive medication and antihypertensive treatment would, in and of itself, have minimum effects on the results of the present study.
In the present study, an index called stiffness was calculated using an ultrasound instrument to assess bone mineral density. Ultrasound velocity has been shown to be a good predictor of the bone mineral density determined by x-ray absorptiometry.\textsuperscript{12} In simple correlation analyses, SBP and DBP were significantly correlated with bone stiffness in men, but not in women in this study population. Furthermore, bone stiffness was independently and significantly associated with DBP, but not with SBP in men, after controlling for factors including serum creatinine, BMI, number of teeth, corrected serum calcium, current smoking, and habitual alcohol intake. Few studies have examined the association between blood pressure and bone mineral density. The Rotterdam Study\textsuperscript{20} reported an inverse relationship between DBP and bone mineral density assessed by x-ray. The Rotterdam Study did not consider the gender differences in bone mineral density, and the subjects participating in that study were younger than the participants in the present study.\textsuperscript{20} In another study, Cappuccio, \textit{et al}\textsuperscript{21} demonstrated that higher blood pressure in elderly white women (mean age 73 years) is associated with increased bone loss at the femoral neck. In contrast, in the present study, the subjects were 80 years old, and the association between DBP and bone stiffness assessed by ultrasound was found only in men. The different profiles of the subjects studied, such as age, race, and body weight, may account for the dissociated results of the present and previous studies.

In conclusion, a close inverse relationship between heart rate and the number of teeth was found in 80-year-old Japanese subjects. After controlling for factors including sex, corrected serum calcium concentrations, current smoking status, SBP, BMI, bone stiffness, physical ability, and alcohol intake, the inverse association between heart rate and number of teeth remained highly statistically significant. On the other hand, bone stiffness was independently and significantly associated with DBP, but not with SBP in men, after controlling for factors including serum creatinine, BMI, number of teeth, corrected serum calcium, current smoking, and habitual alcohol intake. Heart rate has been shown to be one of the predictors of cardiovascular mortality and morbidity; therefore, the number of teeth also may predict cardiovascular mortality and morbidity in the elderly. Further studies will be needed to determine whether dental status predicts cardiovascular morbidity and mortality in the very elderly.

\textbf{REFERENCES}