Changes in the Prevalence of Hypertension and Obesity in a Rural Area of Japan

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Summary: A systematic epidemiological study was conducted on 40 to 64 year old male inhabitants of an agricultural village in Kyushu in 1958 and 1977. The study investigated the prevalence of obesity and its relationship to hypertension. 1) The mean body weight of the subjects at each body height was significantly higher in 1977 than in 1958. The prevalence of obesity based on relative body weight was significantly higher in 1977. This increase was especially pronounced in the 40-49 age group. 2) The prevalence of hypertension was nearly the same in lean, intermediate, and obese body types in 1958. There was a general increase in the number of hypertensive subjects in 1977, and the increase was greater in the obese group than in the other two groups. 3) The mean serum cholesterol levels were not different among the different body types in 1961. In 1977, significantly higher cholesterol values within the normal range were obtained in the obese group than in the lean group, especially at 40-49 and 50-59 years of age. No difference was noted in the prevalence of hypercholesterolemia (above 250 mg/dl). These observations indicate that changes in the health and disease structure of Japan have resulted from the modifications in the Japanese life style such as diet.

Key words: epidemiological study — hypertension — obesity — relative body weight — body mass index — hypercholesterolemia — ischemic heart disease — stroke

Introduction

The Japanese have experienced amazing changes in their life style since the second World War. There were pronounced changes in the quantity and quality of nutritional intake, which favorably influenced the nation’s health.

The recent change from the traditional Japanese life style toward the American and European life styles has increased the incidence of obesity. This problem has become so prevalent that it even involves schoolchildren. There has also been a remarkable improvement in the nutritional intake and body structure of the Japanese people.

The causes of death in Japan have also changed during this time. Death due to cerebral hemorrhage has decreased mark-
edly from its peak in 1960. At the same
time cerebral infarction and ischemic heart
disease has increased gradually as causes
of death. The changes of health and dis-
ease structure are thus more evident in
Japan than in most other nations. The
purpose of this study was to investigate
the relationship between obesity and hy-
pertension within a single environment.

Materials and Methods

This study was conducted on 639 male
subjects in 1958 and 573 male subjects in
1977 between the ages of 40 and 64 years.
All the subjects resided in the agricultural
area of Kawai and Shibakari in Tanushimaru-machi, Ukiha-gun, Fukuoka Prefecture, where the epidemiological study was initiated as part of a Seven Countries Study (Keys et al. 1967). The survey was conducted from mid March to mid April, 1958 and from mid September to mid October, 1977. The response rate to the sur-
vey was 100% and 91% respectively (Ta-
ble 1). The small number of subjects at
the age of 55-64 in 1977 was due to deaths
during World War II.

The method was based on the unified
procedure in the Seven Countries Study
(Keys et al 1967; 1970; 1980). This pro-
cedure utilized height (cm), body weight
(kg), body mass index (BMI), relative
body weight (RBW, %), blood pressure
(mmHg) and serum cholesterol concen-
tration (mg/dl) for analysis.

Each subject’s blood pressure was mea-
sured in the supine position. Before meas-
uring the blood pressure the subject was
requested to urinate, refrain from smok-
ing, have his body measurements taken
and medical history recorded. More than
30 minutes elapsed between reception and
blood pressure measurement. This interval

<table>
<thead>
<tr>
<th>Age group</th>
<th>1958</th>
<th>1977</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-44</td>
<td>112</td>
<td>152</td>
</tr>
<tr>
<td>45-49</td>
<td>117</td>
<td>168</td>
</tr>
<tr>
<td>50-54</td>
<td>137</td>
<td>152</td>
</tr>
<tr>
<td>55-59</td>
<td>143</td>
<td>71</td>
</tr>
<tr>
<td>60-64</td>
<td>130</td>
<td>87</td>
</tr>
<tr>
<td>Total</td>
<td>639</td>
<td>630</td>
</tr>
</tbody>
</table>

( ) : Number of examined subjects

should have greatly reduced the influence
of a full urinary bladder, smoking, and
physical movement on blood pressure. The
values obtained probably represent blood
pressure during relaxation.

RBW was calculated according to the
method in the Framingham study (Kannel
et al, 1967). The mean body weight for
each group of subjects at each body height
(Table 2) was determined for each survey
year. Individual RBW’s were calculated
based on the average (100 %) RBW of the
group. Subjects with RBW values below
85 % were defined as lean, those between
85 and 115 % as intermediate, and those
above 115 % as obese. Serum cholesterol
concentrations were measured using the
method of Abell et al. (1952), as modified
by Anderson and Keys (1956) in 1961 and
by the peroxidase method in 1977. Hyper-
tension (HT) was defined as a systolic
blood pressure above 160 mmHg or a dias-
tolic blood pressure above 95 mmHg, nor-
motension (NT) as a systolic pressure be-
low 140 mmHg and a diastolic pressure be-
low 90 mmHg, and borderline hypertension
(BHT) as the intermediate range (WHO,
1962). Differences between groups were
statistically evaluated by a Student’s t
test.
HYPERTENSION AND OBESITY

TABLE 2

*Body weight for each height group in 1958 and 1977*

<table>
<thead>
<tr>
<th>Height (cm)</th>
<th>1958</th>
<th>1977</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean (kg)</td>
<td>SD</td>
</tr>
<tr>
<td>154≥</td>
<td>127</td>
<td>50.8</td>
<td>5.66</td>
</tr>
<tr>
<td>155 - 159</td>
<td>184</td>
<td>53.3</td>
<td>5.12</td>
</tr>
<tr>
<td>160 - 164</td>
<td>208</td>
<td>57.2</td>
<td>6.19</td>
</tr>
<tr>
<td>165≤</td>
<td>120</td>
<td>61.0</td>
<td>6.94</td>
</tr>
</tbody>
</table>

TABLE 3

*Prevalence of obesity on initial examination in 1958 and 1977 (The men were 40 to 64 years old.) TANUSHIMARU [Kawai and Shibakari]*

<table>
<thead>
<tr>
<th>Age Group</th>
<th>1958</th>
<th>1977</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Number of obese subjects</td>
<td>%</td>
</tr>
<tr>
<td>40 - 49</td>
<td>229</td>
<td>19</td>
<td>8.3</td>
</tr>
<tr>
<td>50 - 59</td>
<td>280</td>
<td>32</td>
<td>11.4</td>
</tr>
<tr>
<td>60 - 64</td>
<td>130</td>
<td>6</td>
<td>4.6</td>
</tr>
<tr>
<td>Total</td>
<td>639</td>
<td>57</td>
<td>8.9</td>
</tr>
</tbody>
</table>

RBW=Tanushimaru relative body weight
Obesity : RBW ≥115 N : Number of subjects

Results

1) *Changes of body weight (Table 2).*

The group with a body height of 160-164 cm was the largest in 1958 with 208 of 639 subjects (32.6%). The group with a body height below 154 cm consisted of 127 subjects (19.9%). However, in 1977, 223 of 573 subjects (38.9%) had a body height greater than 165 cm, demonstrating a pronounced increase in body height over the 20 year period. During this same time, the mean body weight for each body height group increased significantly with a greater tendency toward obesity in 1977 (p<0.05-p<0.001).

2) *Changes in the prevalence of obesity and hypertension based on RBW.*

Table 3 summarizes the prevalence of obesity based on RBW in 1958 and 1977. The prevalence of RBW above 115% was significantly higher in 1977 (13.9%) than in 1958 (8.3%) within the relatively young age group of 40-49 years (p<0.05).

An overall significant increase from 8.9% to 12.6% was noted (p<0.05). The prevalence of hypertension by body type in 1958 (Fig. 1) revealed no difference between the different body types in the age groups 40-49 and 50-59. The prevalence of hypertension for all age groups was not higher in the obese than in the non-obese subjects. However, Fig. 2 illustrates that hypertension was seen more frequently in the obese subgroup (34.6%) than in the intermediate (18.9%) or lean subgroups (5.3%) in subjects between the ages of 50 and 59 in 1977 (p<0.05). Similar tendencies were observed in the 40-59 age group (p<0.05).
Fig. 1. Prevalence of hypertension at each relative body weight in 1958 (No differences were significant at 0.05 level.)

Fig. 2. Prevalence of hypertension at each relative body weight in 1977
3) Changes in the prevalence of obesity and hypertension based on BMI.

The subjects were classified into 3 types, lean with a BMI below 20, intermediate with a BMI between 20 and 25, and obese with a BMI above 26. No difference in the prevalence of hypertension was noted between the body types in 1958 (Fig. 3). These results were similar to those obtained for RBW (Fig. 1). However, in 1977 the prevalence of hypertension was 5.7% in the lean group, 18.6% in the intermediate group, and 41.4% in the obese group in the 50-59 age range (Fig. 4).

**Fig. 3.** Prevalence of hypertension at each body mass index in 1958 (No differences were significant at 0.05 level.)

**Fig. 4.** Prevalence of hypertension at each body mass index in 1977.
This indicates that a relationship exists between hypertension and obesity. This tendency was also evident in the age range of 40–59 years. Even when all subjects were compared, the prevalence of hypertension was significantly higher in the obese subjects.

4) Mortality rate during the 15 year period based on RBW.

Table 4 shows the overall mortality rate during the 15 year period after 1958. The mortality rate tended to be higher in the lean group than in the obese group, to 60 years. The overall mortality rate was 46.7% for the lean group, 23.7% for the intermediate group, and 22.8% for the obese group. These results indicate that there was a significantly higher mortality rate for the lean subjects.

5) Changes of mean serum cholesterol concentrations based on RBW.

Table 5 shows the mean serum cholesterol concentrations in 1961 and 1977, by age group and RBW. No differences in serum cholesterol were noted at any RBW or age group in 1961. Significantly higher

| TABLE 4 |

<table>
<thead>
<tr>
<th>Fifteen-year mortality rate at each relative body weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>R BW</td>
</tr>
<tr>
<td>Age Group</td>
</tr>
<tr>
<td>40 - 49</td>
</tr>
<tr>
<td>50 - 59</td>
</tr>
<tr>
<td>60 - 64</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

N : Number of subjects

| TABLE 5 |

<table>
<thead>
<tr>
<th>Total serum cholesterol concentration at each relative body weight in 1961 and 1977</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age Group</td>
</tr>
<tr>
<td>RBW</td>
</tr>
<tr>
<td>40 - 49</td>
</tr>
<tr>
<td>85 - 114 172 149.4 39.65 N S</td>
</tr>
<tr>
<td>≥115 17 144.4 40.12</td>
</tr>
<tr>
<td>50 - 59</td>
</tr>
<tr>
<td>85 - 114 192 145.1 36.64 N S</td>
</tr>
<tr>
<td>≥115 29 164.3 46.11</td>
</tr>
<tr>
<td>60 - 64</td>
</tr>
<tr>
<td>85 - 114 87 151.4 41.81 N S</td>
</tr>
<tr>
<td>≥115 4 146.8 45.32</td>
</tr>
</tbody>
</table>
values were obtained in the obese group (p<0.001) in the 40-49 age range in 1977. A significant difference was also noted between the lean and obese groups in the 50-59 age range; however, no significant difference was noted between the three weight groups in the 60-64 age range.

Discussion

Obesity is defined as a state of excessive deposition of fat in tissue. Obesity is generally classified into constitutional and symptomatic varieties. However, as few as 1-2% of obese patients are symptomatic. Most cases of obesity are exogenous due to excessive food intake. Consequently, changes in the style of living can have an important impact on the development of obesity. There would be changes in nutritional intake and in physical activity after modernization of industry and of transport.

The data on the development of obesity revealed a marked increase of body height between 1958 and 1977. A significant increase of mean body weight at each body height was also noted (Table 2). The incidence of obesity based on RBW increased in each age group. This increase was especially significant at 40 to 49 years of age (Table 3).

According to a report of the Japanese Nutritional Survey (1977), the mean body height of males in their 40s in 1958 was 159.9 cm and the mean body weight was 55.1 kg. The mean body height of males in their 50s was 158.4 cm and the mean weight was 54.0 kg. In 1977, the mean body height of males in their was 162.8 cm and the mean body weight was 60.1 kg. The corresponding values of males in their 50s were 161.1 cm and 58.5 kg. This indicates that there was a definite increase of both body height and body weight over the 20 year interval.

Such a phenomenon may be markedly influenced by changes in the pattern and amount of nutritional intake (Kimura 1983) and a decrease of physical activity due to the modernization of the nation's living environment. This information provides an example of the importance of environmental factors on the human body.

As to the differences in blood biochemistry, the authors observed a significant increase of serum protein and albumin at all ages in the 10 year period between 1968 and 1977 (Toshima et al. 1980). The serum albumin was increased by an average of 0.7 g/dl. No difference was seen in the prevalence of hypercholesterolemia (above 220 mg/dl); whereas hypocholesterolemia (below 140 mg/dl), probably due to a dietary cause, was markedly decreased from 46.9% in the 40-49 age group in 1961 to 24.6% in 1977. The mean serum cholesterol concentration in each RBW group was compared in 1961 and 1977. No differences were noted in 1961; but in 1977, significantly higher values were noted in obese subjects in their 40s than in lean and intermediate subjects. Significantly higher values were found in the obese group in their 50s than in the lean group (Table 5).

Direct comparisons of serum cholesterol concentrations in the present study might present some problems, since the method of Abell et al. (1952) modified by Anderson and Keys (1956) was used for measuring cholesterol in 1961, and the enzymatic method was used in 1977. However, results of the cross-sectional study in 1977, showed serum cholesterol to be significantly higher in the obese group than in the lean and intermediate groups at a relatively young age (Table 5).

The prevalence of definite hypercholesterolemia (above 250 mg/dl) in 1977 was 1.7% in the lean type, 0.9% in the intermediate type, and 1 of 72 or 1.4% in the obese type. There was no remarkable difference between the three groups. Hypercholesterolemia was found in only 6 of
569 (1.1%) subjects. Thus serum cholesterol appears to be lower in this area of Japan than in Europe or the United States. The average serum cholesterol level of the obese type appears to be higher than the other body types. Attention should be focused on future trends.

Levy (1946) studies 22,741 army officers to estimate the prognosis of obese subjects. Death due to cardiovascular and renal disease was frequent among obese subjects with hypertension. Hypertension and obesity markedly increased the mortality rate, according to this report. In a report from the Framingham study, Kannel et al. (1967) found that obesity was an important coronary risk factor based on follow-up studies on 5,127 males and females over more than 12 years. The mortality rate was very high in obese subjects with hypercholesterolemia and hypertension. The presence or absence of these risk factors probably influenced the prognosis.

The rate of survival is by no means low in obese subjects, according to the results from the follow-up studies by Breslin et al. (1966) on 540 subjects with essential hypertension. The rate of survival was higher for obese patients than for a group of patients with abnormal eye ground findings. No consensus has yet been achieved as to the prognosis of obese individuals.

The prognosis over a period of 15 years after 1958 in the present study is summarized in Table 4. In the 60 age range, the mortality rate was higher in the lean subjects than in the obese subjects. The mortality rate at all ages was significantly higher for the lean subjects than for the intermediate and obese subjects. Consequently, at least in the subjects included in the present study, a lean body weight appears to lead to a higher morbidity than an obese body weight.

There was no apparent relationship between hypertension and obesity in the results for 1958 (Fig. 1). This is in agreement with the report of Komachi et al. (1971) on the absence of a relationship between obesity and hypertension in the general population. This is one finding which leads to a more favorable prognosis for obese subjects than for lean subjects.

The trend toward increased body weight observed in this area between 1958 and 1977 occurs simultaneously with a rise in blood pressure. The incidence of hypertension in the obese group is markedly elevated (Figs. 2, 4). This is probably due to changes in many environmental factors, including diet.

The follow-up survey in the NI-HONSAN study (Kagan et al. 1974) illustrates the influence of environmental changes on the Japanese people. Body weight, skinfold thickness and serum cholesterol concentrations were significantly higher in Japanese living in Hawaii and San Francisco than in Japanese living in Japan. The mortality rate due to cerebral apoplexy was about twice as high in Japanese living in Japan as in Japanese living in Hawaii and San Francisco. However, the mortality rate due to ischemic heart disease in Japanese living in Japan was only about 1/2 that for Japanese living in Hawaii and San Francisco (Kato et al. 1977). This indicates that changes of physical conditions occur in response to environmental factors, such as diet, with subsequent changes in disease structure, even with homogeneous hereditary factors.

An increase of atheromatous diseases such as myocardial infarction, dissecting aneurysm and cerebral infarction has occurred in Japan in recent years. Many Japanese patients with cerebral apoplexy have arterionecrotic-thrombotic cerebral apoplexy (Yamori et al. 1977) which is influenced by hypertension as a risk factor.

The traditional Japanese diet was low in protein, low in fat, high in carbohydrates and especially high in salt. This diet is an important factor in the incidence of cerebral apoplexy (Kimura et al. 1972, 1977,
1979; Komachi et al. 1969; Yamori et al. 1979). The need for an increase in protein and fat intake has been emphasized as a countermeasure, after taking into consideration the quality of fat. This should not have been done excessively. The addition of some European-American type food seems to be ideal. Japan has already successfully prevented ischemic heart disease, as seen in the report from the 10 year follow-up study of the Seven Countries Study (Keys et al. 1980).

It must be pointed out that the value of the complete European-American diet is doubtful as present. At this point it should be emphasized that the past dietary habits of the Japanese has already been modified through public education.

The results of this study demonstrate a tendency toward obesity and a general increase in the frequency of hypertension. The relationship between obesity and hypertension became clear, especially in the relatively young age group. Further studies on this group should be interesting.

In general, several steps are recognized in the relationship between body type, blood pressure, and serological background, but the mechanisms are quite complex (Sims and Berchtold, 1982). Obesity is important, but the combined effects of hypertension, hypercholesterolemia, habitual smoking, diabetes mellitus, and other risk factors in aggravating the prognosis should not be forgotten.

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References


