

# A 50-year history of the health impacts of Westernization on the lifestyle of Japanese Americans: A focus on the Hawaii–Los Angeles–Hiroshima Study

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## Keywords

Diabetes, Lifestyle, Obesity

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## ABSTRACT

A medical survey of Japanese Americans have been carried out since 1970; in particular, this survey was administered to the Japanese emigrants from Hiroshima (Japan) to Hawaii or Los Angeles (USA) and their offspring. Labeled the Hawaii–Los Angeles–Hiroshima Study, it constituted a long-term epidemiological study of Japanese Americans who are genetically identical to the native Japanese people, but have experienced rapid and intense Westernization in terms of their lifestyles. The authors have compared the medical survey data procured from two Japanese populations, evincing very disparate lifestyles; that is, the native Japanese inhabitants of Hiroshima (Japan) and Japanese Americans living in Hawaii or Los Angeles (USA). The focus was particularly on differences in the intake of nutrients, the frequency of obesity, the prevalence of metabolic syndrome and diabetes mellitus, and the progression of atherosclerosis. The authors believe that the health effects of the lifestyles of Japanese Americans can predict the imminent health prospects of native Japanese people who adopt Westernized lifestyles in Japan. This review thus summarized the major results accumulated from the Hawaii–Los Angeles–Hiroshima Study over the past 50 years.

## INTRODUCTION

Westerners and Asians differ in race. If the countries they reside in are different, their living environments (including their dietary habits) are different, and thus, the structure of the diseases developing in those living environments will be different. For example, the diagnostic criterion for obesity in Europe and the USA is body mass index (BMI)  $\geq 30$  kg/m<sup>2</sup>, whereas in Japan, it is BMI  $\geq 25$  kg/m<sup>2</sup>. The incidence<sup>1,2</sup> and prevalence<sup>3,4</sup> of diabetes mellitus are higher in Asians than in white people of the same BMI. Asian people are at higher risk of developing diabetes mellitus at a low or non-obese BMI than white people of the equivalent BMI.

Japanese people began to emigrate in the late 19th century. Lifestyle habits, including diet and exercise, were vastly different in Japan and the USA at that time. First-generation Japanese Americans (JA-1), who were born in Japan and emigrated from Japan to various parts of the USA, changed their lifestyle habits

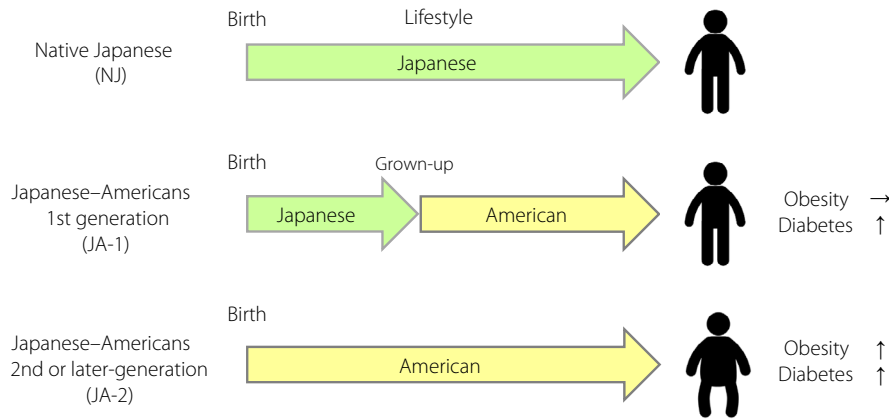
rapidly to suit the American environment. Their descendants, the second- or later-generation Japanese Americans (JA-2), were born and raised in the American environment and lifestyle (Figure 1).

The Hawaii–Los Angeles–Hiroshima Study is a long-term epidemiological investigation involving two populations of Japanese people who have identical genetic predispositions, but different lifestyles: a group of Japanese Americans who have acquired an American lifestyle, and a group of native Japanese people who follow a Japanese lifestyle in Hiroshima. The influence of lifestyle Westernization on the features of illness among Japanese people over the past 50 years has been investigated and reported through comparative analyses of the medical survey data procured longitudinally from the two groups (Figure 2).

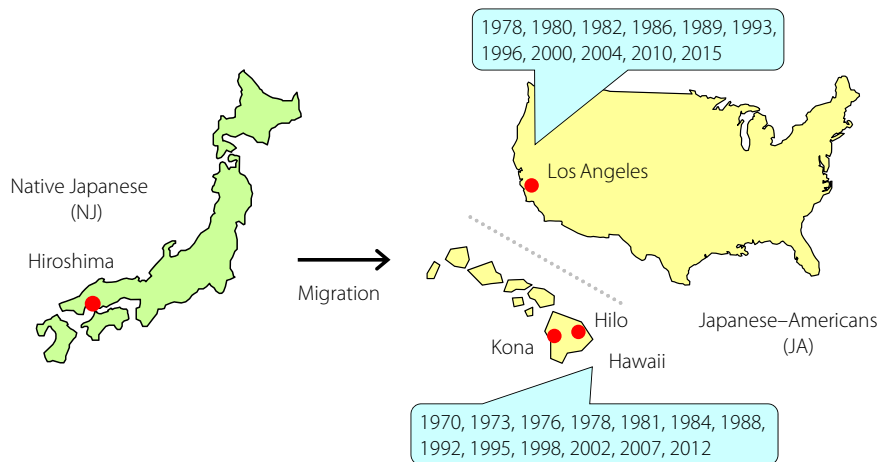
## METHODS

The medical survey of Japanese Americans in Hilo and Kona on the island of Hawaii began in 1970, and was expanded to Los Angeles, California, in 1978; since then, medical examinations

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**Figure 1** | Westernization of the lifestyle of Japanese migrants (Japanese Americans) to the USA.



**Figure 2** | The Hawaii–Los Angeles–Hiroshima Study. The medical survey of Japanese Americans began in Hilo and Kona on the island of Hawaii in 1970 and in Los Angeles in 1978. The medical survey data have been compared between Japanese Americans and native Japanese people in Hiroshima.

have been carried out every few years in each district with the cooperation of the members of the Hiroshima Kenjin-kai, an association of Japanese migrants from the Hiroshima Prefecture and their descendants. An aggregate of 24 rounds of medical examinations was accomplished by 2015, and a total number of 13,289 had participated in the study (Table 1).

After fasting overnight, each participant was interviewed, and then underwent a physical examination and a blood test. The BMI of the participants was calculated by dividing weight (kg) by height squared (m<sup>2</sup>). An oral glucose tolerance test was carried out for all non-diabetic participants. Each venous blood sample was centrifuged, and the obtained serum samples were immediately frozen and stored until analysis.

The participants were classified into a normal glucose tolerance group (NGT; a fasting serum glucose level of <110 mg/dL plus a 2-h serum glucose level of <140 mg/dL), a diabetes mellitus group (fasting serum glucose level of ≥126 mg/dL or 2-h serum glucose level of ≥200 mg/dL) and an impaired glucose

tolerance group (fasting serum glucose and 2-h serum glucose values that were between those of the NGT and diabetes mellitus groups). All participants received an explication of the study's procedures and provided written informed consent. This epidemiological study was carried out in accordance with the Helsinki Declaration, and was approved by the Ethics Committee of Hiroshima University.

## RESULTS AND DISCUSSION

The main results of the study are presented below by age group.

### 1970s and 1980s

Japanese migrants and their offspring on the island of Hawaii and native Japanese people living in Hiroshima were examined for diabetes mellitus and its vascular complications in the surveys carried out in 1973 and 1976<sup>5</sup>. The prevalence of diabetes was significantly higher among Japanese Americans in Hawaii than among the native Japanese people living in Hiroshima.

**Table 1** | Study participants of the medical survey of Japanese Americans carried out between 1970 and 2015 (total 13,289 persons)

	Hawaii (Hilo, Kona)		Los Angeles
1st (1970)	478		
2nd (1973)	840		
3rd (1976)	568		
4th (1978)	469	4th (1978)	271
		5th (1980)	594
6th (1981)	553	7th (1982)	703
8th (1984)	575	9th (1986)	859
10th (1988)	526	11th (1989)	814
12th (1992)	475	13th (1993)	875
14th (1995)	416	15th (1996)	760
16th (1998)	349	17th (2000)	591
18th (2002)	306	19th (2004)	597
20th (2007)	260	21st (2010)	626
22nd (2012)	200	23rd (2015)	584

The proportion of deaths attributed to ischemic heart disease was higher in Japanese Americans both with and without diabetes in Hawaii than in diabetic patients in Japan, and Japanese Americans and white Americans in Hawaii evinced similar rates of the incidence of ischemic heart disease.

In the surveys carried out between 1978 and 1988, no significant difference was observed in the total energy intake of Japanese Americans living in Hawaii or Los Angeles and the native Japanese people living in Hiroshima for both men and women<sup>6</sup>. However, the intake of animal fat and simple carbohydrates (particularly fructose) was markedly greater, and the ingestion of complex carbohydrates was lower in Japanese Americans than in the native Japanese residents of Hiroshima.

Using data from these surveys, the frequency of obesity, defined by a BMI of  $\geq 25$  kg/m<sup>2</sup>, and the prevalence of diabetes mellitus were compared among the Japanese participants of the three regions; namely, Hawaii, Los Angeles and Hiroshima<sup>7</sup>. The frequency of obesity was found to be significantly higher among Japanese American men, but there was no discernable difference observed among the women of the three regions. The age- and sex-adjusted prevalence of diabetes in Hawaii, Los Angeles and Hiroshima were found to be 18.3%, 13.4% and 6.2%, respectively; in other words, the prevalence of diabetes was two- to threefold higher among Japanese Americans than among native Japanese people.

The age- and sex-adjusted prevalence of hypertension in Hawaii, Los Angeles and Hiroshima were found to be 42.6%, 37.2% and 29.7%, respectively, in the surveys carried out in 1986 and 1988<sup>8</sup>.

### 1990s

The birthplace, the location where the participant grew up, and the place of residence of Japanese Americans were different for JA-1 and JA-2 in comparison with the relatively static

residential status of intergenerational native Japanese in Hiroshima. Given this fact, the surveys carried out between 1992 and 1995 divided the Japanese Americans into two subgroups by generation (JA-1 and JA-2), and compared nutritional data between JA-1, JA-2 and the native Japanese group<sup>9</sup>. For both men and women, the percentage of animal protein, animal/vegetable fat and simple carbohydrate intake was highest in JA-2, followed by JA-1, with the native Japanese group reporting the least ingestion of these nutrients. In contrast, the percentage of complex carbohydrate intake was found to be the highest in the native Japanese group, followed by JA-1 and JA-2.

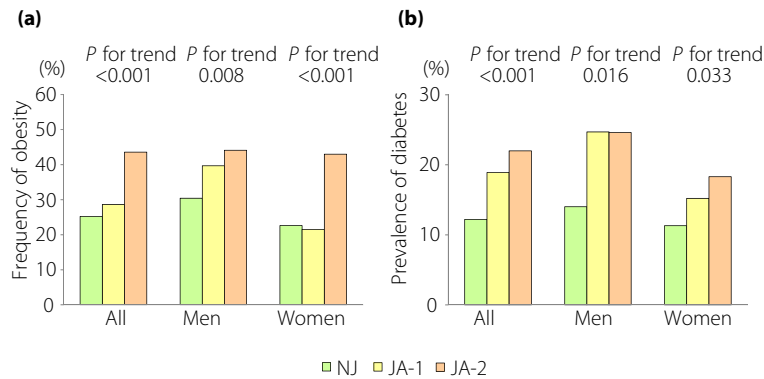
The 1998 survey carried out in Hawaii measured the carotid intima-media complex thickness (IMT) of participants to evaluate the relationship between lifestyle Westernization and atherosclerosis<sup>10</sup>. The carotid IMT was found to be significantly greater among Japanese Americans ( $1.20 \pm 0.03$  mm [mean  $\pm$  standard error]) than among native Japanese people ( $0.98 \pm 0.03$  mm [mean  $\pm$  standard error]). Furthermore, Japanese Americans were found to attain an IMT of 1.1 mm at age 50 years, whereas native Japanese people reached this value at age 70 years. Put differently, the progression of atherosclerosis was found to be faster by approximately 20 years in Japanese Americans than in native Japanese people.

### 2000s

The 2004 survey carried out in Los Angeles compared the prevalence of metabolic syndrome, which was found to be significantly higher in Japanese American men than in native Japanese men<sup>11</sup>. The prevalence of metabolic syndrome differed greatly among the women of the two groups according to the diagnostic criteria. In general, however, Japanese American men and women showed more metabolic abnormalities.

The frequency of obesity (a BMI of  $\geq 25$  kg/m<sup>2</sup>) and the prevalence of diabetes mellitus in the JA-1, JA-2 and native Japanese group were compared in the surveys carried out in 2007 and 2010<sup>12</sup>. The frequency of obesity was found to be 25.2, 28.6 and 43.6%, and the prevalence of diabetes was found to be 12.2, 18.9 and 22.0% in the native Japanese group, JA-1 and JA-2, respectively (Figure 3). Japanese people are genetically predisposed to low insulin secretion. These results, therefore, suggest that abnormal glucose tolerance is likely to develop before the onset of obesity if Japanese migrants (JA-1) follow the American lifestyle even for a relatively short period. Meanwhile, Japanese Americans (JA-2) who are continuously exposed to the American lifestyle for a long period after birth are more likely to become obese (Figure 1).

The 2010 survey carried out in Los Angeles compared serum total adiponectin levels between native Japanese people and Japanese Americans in terms of their glucose tolerance status; namely, NGT, impaired glucose tolerance and diabetes mellitus groups<sup>13</sup>. The serum total adiponectin levels were significantly lower in Japanese Americans than in native Japanese people in the NGT and impaired glucose tolerance groups, but not in the diabetes mellitus group.



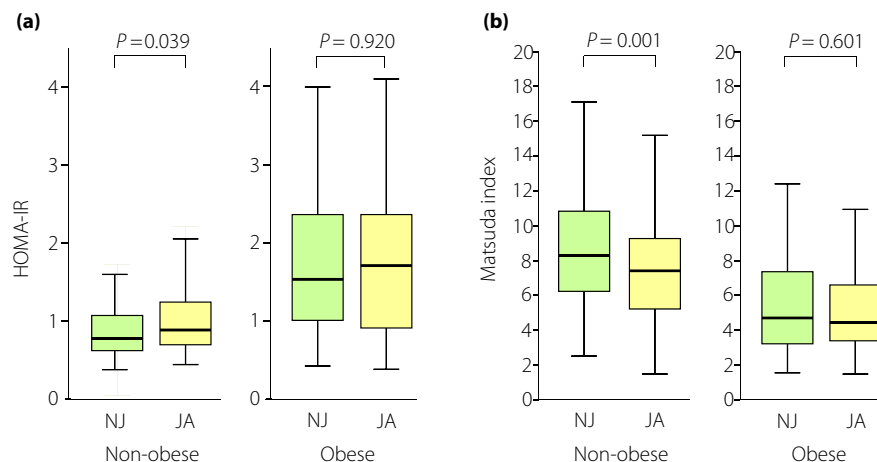
**Figure 3** | (a) Frequency of obesity and (b) prevalence of diabetes mellitus in native Japanese people and Japanese Americans by generation found in the 2007–2010 surveys. A total of 516 native Japanese people (NJ; 171 men and 345 women), 444 first-generation Japanese Americans (JA-1; 174 men and 270 women), 337 second- or later-generation Japanese Americans (JA-2; 195 men and 142 women). ■ (green), NJ; ■ (yellow), JA-1; ■ (orange), JA-2. [Colour figure can be viewed at wileyonlinelibrary.com]

Furthermore, among the participants included in the report<sup>13</sup>, those with NGT were divided into a non-obese group (a BMI of  $< 25 \text{ kg/m}^2$ ) and an obese group (a BMI of  $\geq 25 \text{ kg/m}^2$ ): the number of native Japanese and Japanese Americans in the non-obese and the obese groups were 190 and 57, and 186 and 51, respectively. Additionally, insulin resistance between native Japanese people and Japanese Americans was compared, and the results showed that Japanese Americans, even in the non-obese group, had high homeostasis model assessment of insulin resistance levels and low Matsuda Index levels (Figure 4). In other words, regardless of obesity, their insulin resistance was aggravated compared with the native Japanese people.

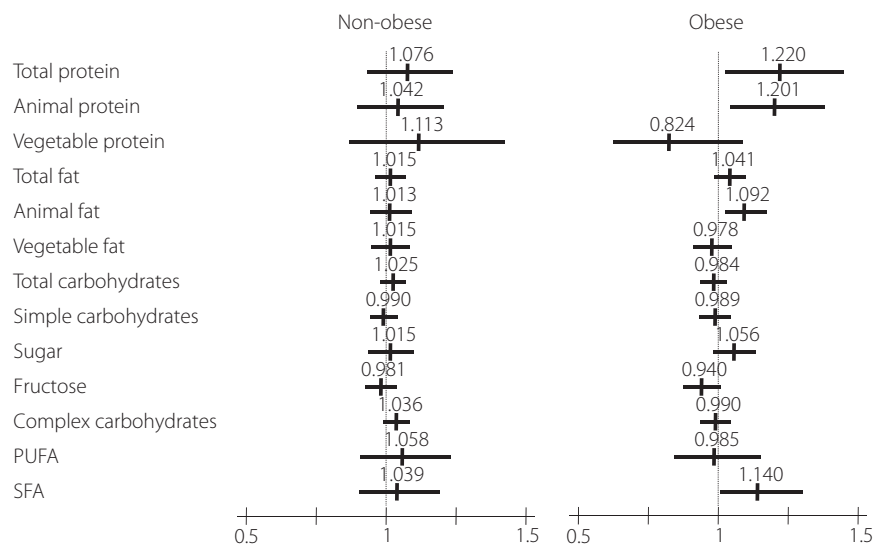
According to the 2012 survey carried out in Hawaii, the carotid IMT was still greater in Japanese Americans than in the native Japanese group<sup>14</sup>. However, the progression of

atherosclerosis among native Japanese people in this survey was found to be more advanced than was reflected in the 1998 survey, and this progression was comparable to the advancement observed in Japanese Americans.

The gut microbiota composition of non-diabetic men was compared between native Japanese people and Japanese Americans in the 2015 survey in Los Angeles<sup>15</sup>. The percentage of the phylum Bacteroidetes was lower, whereas the percentage of phylum Firmicutes was higher in Japanese American men than in native Japanese men. Subsequently, the proportions of the genus *Collinsella* within the phylum Actinobacteria, and the genus *Parabacteroides* and *Odoribacter* within the phylum Bacteroidetes were lower, whereas the proportion of the genus *Faecalibacterium* within the phylum Firmicutes was higher in Japanese American men than in native Japanese men.



**Figure 4** | Comparison of insulin resistance in the normal glucose tolerance group in the 2010 survey. (a) Homeostasis model assessment of insulin resistance (HOMA-IR). (b) Matsuda Index. The non-obese group comprised 190 native Japanese people (NJ) and 186 Japanese Americans (JA); the obese group comprised 57 NJ and 51 JA.



**Figure 5** | Association of nutrient intake with diabetes incidence in obese or non-obese Japanese Americans. Non-obese participants and obese participants were 576 and 189 persons, respectively. The hazard ratios and 95% confidence intervals were calculated after adjusting for age, sex, body mass index, systolic blood pressure, serum total cholesterol, triglycerides, fasting glucose and fasting insulin levels. The mean duration of the follow-up period was  $10.8 \pm 6.6$  years (non-obese participants);  $10.7 \pm 6.3$  years (obese participants; mean  $\pm$  standard deviation). PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids.

### Longitudinal analysis

This longitudinal study examined the risk factors for Japanese Americans developing type 2 diabetes mellitus.

First, the relationship between family history and the development of diabetes was investigated by sex<sup>16</sup>. The results showed that even if an individual's lifestyle is Westernized, a family history of diabetes is an important predictor for the onset of diabetes, particularly among Japanese American women.

Furthermore, as serum markers, increased serum C-reactive protein levels<sup>17</sup>, decreased serum adiponectin levels<sup>18</sup> and low levels of serum high-density lipoprotein cholesterol<sup>19</sup> were shown to be significant risk factors for the development of diabetes in Japanese Americans.

Japanese American NGT participants were separated into non-obese participants (those with a BMI of  $<25$  kg/m<sup>2</sup>,  $n = 576$ ) and obese participants (those with a BMI of  $\geq 25$  kg/m<sup>2</sup>,  $n = 189$ ) on the basis of the longitudinal data attained from surveys carried out between 1986 and 2010, and the association of nutrient intakes and the incidence of diabetes was investigated<sup>20</sup>. A total of 36 obese participants developed diabetes, which was positively associated with intakes of total protein, animal protein, animal fat and saturated fatty acid (Figure 5). In the contrast, a total of 41 non-obese participants also developed diabetes without this incidence being associated with any nutrient intake.

### CONCLUSIONS

On the basis of our comparison of the medical survey data of native Japanese people living in Hiroshima and Japanese migrants (Japanese Americans) in Hawaii and Los Angeles, we

believe that obesity, metabolic disorders (such as diabetes) and atherosclerosis can arise from the Westernization of Japanese people's lifestyle. The results of the Hawaii–Los Angeles–Hiroshima Study have shown that native Japanese people must continue the Japanese lifestyle, and that Japanese Americans should adopt the Japanese lifestyle as a preventive measure against the onset of metabolic and atherosclerotic diseases.

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### DISCLOSURE

The authors declare no conflict of interest.

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