Relationship of Consumption of Meals Including Grain, Fish and Meat, and Vegetable Dishes to the Prevention of Nutrient Deficiency: The INTERMAP Toyama Study

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(Received August 7, 2015)

Summary A Japanese-style diet consists of meals that include grain (shushoku), fish and meat (shusai), and vegetable dishes (fukusai). Little is known about the association of such meals (designated well-balanced meals hereafter) with nutrient intake. We therefore examined the frequency of well-balanced meals required to prevent nutrient deficiency. Participants were Japanese people, ages 40 to 59 y, from Toyama, recruited for INTERMAP, in an international population-based study. Each person provided 4 in-depth 24-h dietary recalls (149 men, 150 women). The prevalence of risk ratios of not meeting the Dietary Reference Intakes for Japanese (2015) was calculated. Well-balanced diets were assessed by the Japanese Food Guide Spinning Top. We counted the frequencies of meals in which participants consumed 1.0 or more servings of all 3 dishes categories. We divided the frequency of consumption of well-balanced meals into the following 4 groups: 1.00 time/d, 1.00–1.49 times/d, 1.50–1.74 times/d, and $^{\geq}1.75$ times/d. Compared with participants in the highest frequency group for well-balanced meals, those who consumed well-balanced meals less than once a day had a higher risk of not meeting the adequate intake for potassium and the recommended dietary allowance for vitamin A. Those who consumed well-balanced meals on average less than 1.50 times per day had a higher risk of not meeting the recommended dietary allowance for calcium and vitamin C. Our results suggest that individuals should on average consume well-balanced meals more than 1.5 times per day to prevent calcium and vitamin C deficiencies.

Key Words grain dish, fish and meat dish, vegetable dish, diet quality, Dietary Reference Intakes for Japanese

A Japanese-style diet consists of meals that include grain dishes (shushoku), fish and meat dishes (shusai), and vegetable dishes (fukusai) (1, 2). In Japan, the second term of the National Health Promotion Movement in the 21st century (Healthy Japan 21 [the second term]) started in 2013 (1). One of the goals of the nutritional and dietary habits included in Healthy Japan 21 is to increase the percentage of individuals who eat a balanced diet that includes these three types of dishes (designated well-balanced meals hereafter) more than twice a day. However, little is known about the association of such meals with nutrient intakes (3–6).

The purpose of this study was to examine whether the frequency of consumption of well-balanced meals related to the prevention of nutrient deficiency in Japanese men and women ages 40–59 y in the INTERMAP Toyama Study. The INTERMAP Study is a highly standardized, international cooperative, population-based study on macro-/micronutrients and blood pressure, with dietary nutrient intake evaluated by 4 in-depth 24-h dietary recalls per person.

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All three categories. We defined meals including grain, which participants consumed 1.0 or more servings of one decimal place. We counted frequencies of meals in dish category was counted. We calculated servings to category and the total number of servings for each dishes that contained several food items as the main 12). Moreover, the dish contained more than 1 ingredient in a standard amount, the dish was classified as the relevant category.

Classification of dishes was based on the Japanese Food Guide Spinning Top (2). The definitions of dish category are shown in Table 1. If, for example, a dish contained more than 1 ingredient in a standard amount, the dish was classified as the relevant category. Nutrient intakes were compared with Dietary Reference Intakes for Japanese 2015 (DRIs 2015) (13). For total fat and sodium, intakes more than the tentative dietary goal for preventing lifestyle related diseases (DG) were considered as not meeting the DRIs 2015. For potassium, intake lower than the adequate intake (AI) was considered as not meeting the DRIs 2015. For calcium, vitamin A, thiamine, riboflavin, and vitamin C, intakes lower than the recommended dietary allowance (RDA) were considered as not meeting the DRIs 2015. Similarly, estimated average requirement (EAR) was also used to evaluate the lower intakes of these nutrients. For protein, and iron, the prevalence of intake below RDA was extremely low (data not shown).

Nutrient scores. To evaluate nutrients at the individual level, we created two nutrient scores: nutrient score (AI/RDA) and nutrient score (AI/EAR). Six nutrients, i.e., potassium, calcium, vitamin A, thiamine, riboflavin, and vitamin C, were selected to calculate nutrient scores based on the priorities recommended in DRIs (14). For each nutrient, participants whose consumption was below the AI or RDA based on the DRIs 2015 were assigned a value of 0, and persons whose consumption was at or above the AI or RDA were assigned a value of 1. The total of these six scores was defined as the nutrient score (AI/RDA). Similarly, another nutrient score (AI/EAR) was calculated using the cutoff point of AI or EAR, instead of AI or RDA. These scores ranged from 0 (poor quality diet) to 6 (high quality diet).

Statistical analyses. Although we tried to divide the frequencies of consumption of well-balanced meals in increments of 0.5 times per day from once per day, few participants (17 males, 14 females) consumed well-balanced meals more than twice per day. Therefore, we divided the participants by the frequencies of consumption of well-balanced meals into the following 4 groups: 0.00–0.99 times/d (group 1), 1.00–1.49 times/d (group 2), 1.50–1.74 times/d (group 3), and ≥1.75 times/d (group 4). For descriptive purposes, means and 95% confidence intervals (CIs) were calculated. Tests of linear

| Name of dish category | Main food items | Definition of 1 serving |
|-----------------------|----------------|-------------------------|
| Grain dishes          | Rice, bread, noodles, etc. | 40 g carbohydrate of main ingredient |
| Fish and meat dishes  | Meat, fish, egg, soybean, etc. | 6 g protein of main ingredient |
| Vegetable dishes      | Vegetables, mushrooms, potatoes, seaweed | 70 g of main ingredient 2 |
| Milk                  | Milk and milk products | 100 mg calcium of main ingredient |
| Fruits                | Fruits | 100 g of main ingredient 2 |
| Confectionary, beverages | confectionary, beverages | 200 kcal of main ingredient |

1 100% fruit juice, counted as half the weight of amount actually consumed.
2 100% vegetable juice, counted as half the weight of amount actually consumed.
trends across four groups of frequency of consumption of well-balanced meals were calculated by treating the median frequency values in each group as continuous variables. Pearson’s chi-square test was used to test for differences in the number of male participants across the 4 groups. To investigate the effects of the frequency of consumption of well-balanced diets on nutrient deficiency, logistic regressions were performed with adjustment for sex and age. We calculated the prevalence of risk ratios and 95% CIs of not meeting the DRIs 2015.

We stratified analyses of associations of frequency of well-balanced meals and nutrient intake by sex, and we observed similar results compared to the unstratified analyses (data not shown). Therefore, we showed only data not stratified by sex. We chose a logistic analysis model based on non-log-transformed data. The findings from the transformed data (not shown) were consistent with those from the non-log-transformed analyses.

All statistical analyses were performed using SPSS for Windows version 20 (IBM Corporation, Tokyo, Japan). All p values were two-tailed; p<0.05 was considered significant.

RESULTS

The numbers of group 1, 2, 3, and 4 were 71 (23.7%), 111 (37.1%), 42 (14.0%), and 75 (25.1%), respectively. There was no significant or gender difference among the groups (p>0.05). Characteristics of the male and female participants in the 4 frequency groups based on well-balanced meals are shown in Table 2. For both sexes, there were no significant differences in age or height. Men in group 2 were significantly heavier and had higher BMI than men in group 1. The prevalence of overweight (BMI 25.0 kg/m²) for men in group 2 was higher than in other groups. For women, there were no significant differences in body weights or BMIs among the groups.

Mean dietary intakes according to frequency of well-balanced meals are shown in Table 3. Frequency of consumption of well-balanced meals was also associated positively and significantly with percent energy from protein intake (Pearson product-moment correlation coefficient=0.137, p<0.05). Participants who had a higher frequency of well-balanced meals had significantly higher intakes of energy, sodium, potassium, calcium, iron, thiamine, riboflavin, and vitamin C. Frequency of well-balanced meals was positively and significantly associated with energy-adjusted intakes of sodium, potassium, iron, and thiamine (data not shown). Frequency of consumption of well-balanced meals was associated positively and significantly with nutrient score (AI/RDA) and nutrient score (AI/EAR). Average vegetable dish intake in the group 3 reached approximately 5 servings/d.

The prevalence of risk ratios of not meeting the DRIs 2015 according to the frequency of well-balanced meals is shown in Table 4. There were no associations between the frequency of consumption of well-balanced meals and the prevalent risk for excessive intakes of total fat or sodium. Participants in group 1 were at a significantly higher risk of not meeting the AI of potassium than those in group 4. Compared with participants in group 4, those in group 1, 2, and 3 had a higher risk of not meeting the RDA for calcium. Participants in group 1 had higher risk of not meeting the RDA for vitamin A than those in group 4. Participants in group 3 were at a marginally higher risk of not meeting the RDA for vitamin C than those in group 1 and 2, who had a significantly higher risk than those in group 4.

Compared with participants in group 4, those in group 1 had a higher risk of not meeting the EAR for calcium. Participants in group 1 and 2 had a higher risk of not meeting the EAR for vitamin A, thiamine, and vitamin C.

DISCUSSION

Participants who consumed well-balanced meals less than 1.5 times/d had a lower nutrient score and a higher risk of not meeting the RDA for calcium and vitamin C than those who consumed well-balanced meals 1.75 or more times/d. In comparison with participants in the highest group of frequency for consumption of well-bal-
anced meals, participants in the lowest frequency group had a higher risk of not meeting the AI for potassium and the RDA for vitamin A.

In this study, we assessed nutrient intakes using RDA, AI, and DG. For assessment of sufficiency of nutrient intake in a group, the EAR is used (13). Although, theoretically, the percentage of individuals with intake below EAR corresponds to percentage of deficiency in the group, it is impossible to determine whether an individual consumed more than their requirement (13). The aim of this study was to examine the desirable frequency of well-balanced meals at the individual level. The EAR is the intake level that poses a 50% probability of insufficient level intake and the RDA is the intake level that poses a nearly 0% of deficiency in an individual or the individual in a group (15). If intake is below the RDA, it should aim to approach the RDA for dietary improvement of individuals. Therefore, in this study, we assessed nutrient intake using RDA, as well as EAR.

According to the concept of RDA and AI, the desirable frequency of well-balanced meals is on average more than 1.5 times/d in order to prevent calcium and vitamin C deficiencies. Since group 1 participants had a lower nutrient score and at a higher risk of not meeting the AI for potassium and RDA for vitamin A in comparison with group 4 participants, it has been suggested that consumption of well-balanced meals is necessary at least once a day in order to avoid these nutrient deficiencies.

Table 3. Dietary intakes by frequency of consumption of well-balanced meals including grain dish, fish and meat dish, and vegetable dish. INTERMAP Toyama Study, 1996–1998.

| Frequency of well-balanced meals (times/d) | Group 1 (n=71) | Group 2 (n=111) | Group 3 (n=42) | Group 4 (n=75) | p for trend |
|-------------------------------------------|----------------|----------------|----------------|----------------|-------------|
| Energy (kcal/d)                           | 1,913 (1,821–2,006) | 1,999 (1,918–2,079) | 2,134 (2,020–2,248) | 2,207 (2,103–2,311) | <0.001      |
| Protein (%energy)                         | 15.6 (15.1–16.1) | 15.9 (15.5–16.3) | 16.1 (15.6–16.6) | 16.4 (15.9–16.9) | 0.031       |
| Total fat (%energy)                       | 23.3 (22.1–24.5) | 24.7 (23.8–25.5) | 24.3 (22.8–23.9) | 24.9 (23.8–26.0) | 0.092       |
| Saturated fatty acids (%energy)            | 6.4 (6.0–6.8) | 6.3 (6.0–6.5) | 6.1 (5.6–6.5) | 6.2 (5.9–6.6) | 0.582       |
| Carbohydrate (%energy)                    | 56.3 (54.5–58.0) | 55.0 (53.8–56.2) | 56.4 (54.5–58.4) | 55.3 (53.7–56.8) | 0.657       |
| Alcohol (%energy)                         | 4.7 (3.3–6.2) | 4.4 (3.2–5.6) | 3.1 (1.5–4.6) | 3.4 (2.2–4.7) | 0.105       |
| Sodium (mg/d)                             | 4,346 (4,091–4,601) | 4,582 (4,372–4,792) | 4,961 (4,693–5,230) | 5,461 (5,056–5,886) | <0.001      |
| Potassium (mg/d)                          | 2,533 (2,389–2,677) | 2,722 (2,630–2,813) | 2,921 (2,782–3,060) | 3,280 (3,085–3,476) | <0.001      |
| Calcium (mg/d)                            | 543 (503–582.5) | 592 (560–625) | 579 (529–629) | 667 (623–711) | <0.001      |
| Iron (mg/d)                               | 9.6 (9.1–10.1) | 10.7 (10.3–11.1) | 11.3 (10.8–11.9) | 12.6 (11.9–13.3) | <0.001      |
| Vitamin A (μgRAE/d)                       | 665 (572–758.9) | 1,057 (759–1,155) | 831 (696–967) | 1,015 (879–1,151) | 0.155       |
| Thiamine (mg/d)                           | 0.84 (0.77–0.92) | 0.88 (0.84–0.91) | 0.99 (0.92–1.07) | 1.04 (0.98–1.10) | <0.001      |
| Riboflavin (mg/d)                         | 1.23 (1.16–1.31) | 1.34 (1.25–1.43) | 1.31 (1.22–1.40) | 1.46 (1.37–1.56) | 0.003       |
| Vitamin C (mg/d)                          | 113 (94–132.7) | 125 (110–140) | 115 (104–127) | 147 (129–166) | 0.013       |
| Nutrient score†                           | 2.4 (2.1–2.8) | 2.9 (2.6–3.1) | 2.9 (2.4–3.3) | 3.5 (3.1–3.9) | <0.001      |
| Nutrient score‡                           | 3.4 (3.0–3.9) | 4.0 (3.7–4.3) | 3.8 (3.3–4.3) | 4.2 (3.8–4.6) | 0.016       |
| Grain dish (servings/d)                   | 4.3 (4.0–4.7) | 4.4 (4.1–4.6) | 5.1 (4.7–5.5) | 5.2 (4.8–5.5) | <0.001      |
| Fish and meat dish (servings/d)            | 6.0 (5.4–6.5) | 6.8 (6.3–7.3) | 7.2 (6.5–7.9) | 7.8 (7.2–8.4) | <0.001      |
| Vegetable dish (servings/d)               | 3.4 (3.1–3.8) | 4.2 (4.0–4.4) | 4.9 (4.5–5.4) | 6.1 (5.7–6.5) | <0.001      |
| Milk (servings/d)                         | 1.3 (1.0–1.6) | 1.2 (1.0–1.5) | 0.8 (0.6–1.1) | 1.2 (0.9–1.5) | 0.371       |
| Fruit (servings/d)                        | 1.0 (0.8–1.3) | 1.1 (0.9–1.2) | 1.2 (0.9–1.5) | 1.2 (1.0–1.5) | 0.193       |
| Confectionary (servings/d)                | 0.8 (0.6–1.0) | 0.7 (0.6–0.8) | 0.9 (0.7–1.2) | 0.6 (0.5–0.7) | 0.389       |
| Nonalcoholic drink (servings/d)           | 0.27 (0.19–0.35) | 0.27 (0.20–0.33) | 0.23 (0.16–0.30) | 0.22 (0.15–0.28) | 0.209       |

Values are means (95% confidence intervals).

† Participants whose consumption was below the adequate intake (potassium) or recommended dietary allowance (calcium, iron, vitamin A, thiamine, riboflavin, and vitamin C) were assigned a value of 0, and persons whose consumption was at or above the adequate intake or recommended dietary allowance were assigned a value of 1.

‡ Participants whose consumption was below the adequate intake (potassium) or estimated average requirement (calcium, iron, vitamin A, thiamine, riboflavin, and vitamin C) were assigned a value of 0, and persons whose consumption was at or above the adequate intake or estimated average requirement were assigned a value of 1.
times a day are not possible. Therefore, we set a goal of consuming well-balanced meals 2 times in a single day. Our suggested goal and the goal in Healthy Japan 21 (second term) (1) agree on this point. However, the DRIs are standards for “habitual” intake expressed as “intake per day.” Thus, they apply to long-term rather than short-term (e.g. single-day) intake. This is due to the fact that health problems addressed by the DRIs are caused by habitual inadequate intake (12, 13). Since approximately 1 mo is required for assessing the habitual intake, it is reasonable to propose as a desirable frequency of well-balanced meals 4 times per month, or 11 times per week.

Healthy Japan 21 (second term) recommends that adults consume more than 350 g of vegetables per day (1). For group 3, the mean number of vegetable dishes was approximately 5 servings, i.e., 350 g per day. Consumption of more than 1.5 well-balanced meals per day, when rounded up to twice a day, is associated with an intake of 350 g vegetables a day. Thus, the goals of well-balanced meals matched with those of vegetable intake in Healthy Japan 21 (1). Moreover, our results suggested that those intakes avoid the nutrient deficiency as well as does the intake corresponding to the highest frequency

### Table 4. Odds ratios (ORs)† (95% confidence interval: 95% CI) of not meeting the Dietary Reference Intakes for Japanese 2015 by four groups of frequency of consumption of well-balanced meals including grain dish, fish and meat dish, and vegetable dish. INTERMAP Toyama Study, 1996–1998.

| Frequency of well-balanced meals (times/d) | Group 1 (n=71) (0.00–0.99) | Group 2 (n=111) (1.00–1.49) | Group 3 (n=42) (1.50–1.74) | Group 4 (n=75) (1.75–3.00) |
|-------------------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| **Total fat**                              |                             |                             |                             |                             |
| Number of more than DG (%)                | 5 (7.0%)                    | 16 (14.4%)                  | 7 (16.7%)                   | 10 (13.3%)                  |
| Odds ratio (95% CI)                       | 0.51 (0.16–1.59)            | 0.99 (0.41–2.39)            | 1.26 (0.43–3.72)            | 1.00                        |
| **Sodium**                                |                             |                             |                             |                             |
| Number of more than DG (%)                | 5 (7.0%)                    | 6 (5.4%)                    | 1 (2.4%)                    | 2 (2.7%)                    |
| Odds ratio (95% CI)                       | 0.38 (0.07–2.03)            | 0.48 (0.09–2.46)            | 1.12 (0.10–12.77)           | 1.00                        |
| **Potassium**                             |                             |                             |                             |                             |
| Number of less than AI (%)                | 21 (29.6%)                  | 21 (18.9%)                  | 4 (9.5%)                    | 11 (14.7%)                  |
| Odds ratio (95% CI)                       | 3.00* (1.28–6.69)           | 1.59 (0.70–3.60)            | 0.65 (0.19–2.21)            | 1.00                        |
| **Calcium**                               |                             |                             |                             |                             |
| Number of less than RDA (%)               | 52 (73.2%)                  | 79 (71.2%)                  | 32 (76.2%)                  | 36 (48.0%)                  |
| Odds ratio (95% CI)                       | 3.00** (1.49–6.02)          | 2.70** (1.46–5.00)          | 3.47** (1.49–8.06)          | 1.00                        |
| **Vitamin A**                             |                             |                             |                             |                             |
| Number of less than RDA (%)               | 50 (70.4%)                  | 51 (45.9%)                  | 24 (57.1%)                  | 32 (42.7%)                  |
| Odds ratio (95% CI)                       | 4.00*** (1.95–8.20)         | 1.32 (2.44–0.71)            | 1.99 (0.90–4.39)            | 1.00                        |
| **Thiamine**                              |                             |                             |                             |                             |
| Number of less than RDA (%)               | 63 (88.7%)                  | 103 (92.8%)                 | 34 (81.0%)                  | 59 (78.7%)                  |
| Odds ratio (95% CI)                       | 2.24 (0.88–5.65)            | 3.77** (1.51–9.52)          | 1.20 (0.46–3.13)            | 1.00                        |
| **Riboflavin**                            |                             |                             |                             |                             |
| Number of less than RDA (%)               | 27 (38.0%)                  | 38 (34.2%)                  | 21 (50.0%)                  | 31 (73.8%)                  |
| Odds ratio (95% CI)                       | 0.92 (0.47–1.80)            | 0.77 (0.42–1.42)            | 1.46 (0.68–3.13)            | 1.00                        |
| **Vitamin C**                             |                             |                             |                             |                             |
| Number of less than RDA (%)               | 40 (56.3%)                  | 55 (49.5%)                  | 17 (40.5%)                  | 18 (24.0%)                  |
| Odds ratio (95% CI)                       | 4.39*** (2.14–9.01)         | 3.26*** (1.69–6.29)         | 2.20 (0.97–5.00)            | 1.00                        |
| **Calcium**                               |                             |                             |                             |                             |
| Number of less than EAR (%)               | 43 (60.6%)                  | 49 (44.1%)                  | 20 (47.6%)                  | 26 (34.7%)                  |
| Odds ratio (95% CI)                       | 3.11** (1.57–6.15)          | 1.57 (0.85–2.90)            | 1.76 (0.81–3.83)            | 1.00                        |
| **Vitamin A**                             |                             |                             |                             |                             |
| Number of less than EAR (%)               | 31 (44.9%)                  | 31 (27.9%)                  | 8 (19.0%)                   | 12 (16.0%)                  |
| Odds ratio (95% CI)                       | 5.45*** (2.37–12.55)        | 2.30* (1.05–5.00)           | 1.36 (0.49–3.78)            | 1.00                        |
| **Thiamine**                              |                             |                             |                             |                             |
| Number of less than EAR (%)               | 41 (57.7%)                  | 61.00 (55.0%)               | 22.00 (52.4%)               | 29.00 (38.7%)               |
| Odds ratio (95% CI)                       | 2.35* (1.20–4.60)           | 2.09* (1.14–3.83)           | 1.82 (0.84–3.93)            | 1.00                        |
| **Riboflavin**                            |                             |                             |                             |                             |
| Number of less than EAR (%)               | 7 (9.9%)                    | 13 (11.7%)                  | 9 (21.4%)                   | 6 (8.0%)                    |
| Odds ratio (95% CI)                       | 1.39 (0.44–4.41)            | 1.70 (0.61–4.75)            | 3.36* (1.09–10.35)          | 1.00                        |
| **Vitamin C**                             |                             |                             |                             |                             |
| Number of less than EAR (%)               | 33 (46.5%)                  | 36 (32.4%)                  | 8 (19.0%)                   | 11 (14.7%)                  |
| Odds ratio (95% CI)                       | 5.42*** (2.43–12.08)        | 3.01** (1.41–6.45)          | 1.42 (0.52–3.87)            | 1.00                        |

† Adjusted for sex and age. DG, tentative dietary goal for preventing life-style related diseases; AI, adequate intake; RDA, recommended dietary allowance; EAR, estimated average requirement. *p<0.05, **p<0.01, ***p<0.001.
group for well-balanced diets.

Frequency of consumption of well-balanced meals was positively associated with sodium intake. Excess sodium intake leads to higher risks of hypertension (16), and gastric cancer (17). Compared to the DG, Japanese people have a very high sodium intake (18). Hence, it is necessary to encourage Japanese people to consume low-sodium well-balanced meals.

We mainly investigated the effects of the frequency of consumption of well-balanced meals on nutrient deficiency. The DRIs also provide an index for the objective of preventing lifestyle-related diseases (13, 15). This index is a DG. DGs are determined based on epidemiological studies and the results of interventions. However, the relationship between nutritional intake and the risk of developing life-style related diseases is continuous; no threshold intake exists. We assumed that a threshold intake exists and when the intake is more than the AI or RDA, the risk of nutrient deficiency is near zero. Therefore, assessments in this study cannot be applied for nutrients that have DGs. It is necessary to investigate the relationships between well-balanced meal intake and lifestyle-related diseases.

Fieldwork for the INTERMAP study was conducted from 1996 to 1999, so it is necessary to consider whether the typical Japanese diet has changed since that time. Available data indicates that the Japanese diet has not changed much. For example, according to the National Health and Nutritional Survey in Japan, the percentages of total energy consumed from protein, fat, and carbohydrates were 16.0, 26.3, and 57.7% in 1998, respectively, compared to 14.9, 26.2, and 58.9% in 2013, respectively (19, 20).

There are limitations to this study. Our results cannot be generalized because participant numbers were small and the study conducted in only 1 local area. There have been reports regarding well-balanced meals; however, the definitions of a well-balanced meals differ. In this study, we counted frequencies of meals where participants consumed more than 1.0 serving of each category (grain, fish and meat, and vegetable dishes) according to the Japanese Food Guide Spinning Top.

In conclusion, our results suggest that individuals should consume well-balanced meals more than 1.5 times per day in order to prevent calcium and vitamin C deficiencies.

Acknowledgments

This study was partly supported by a Grant-in-Aid for Scientific Research (A), No. 090357003 from the Ministry of Education, Science, Sports, and Culture of Japan and the Suntory Company. The INTERMAP Study is supported by the National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, MD (Grant 2-ROI-HL50490), as well as national and local agencies in the four countries.

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