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ORIGINAL ARTICLE
Nutrition

Effect of Nutrition Education on the Vegetable Intake of Residents in Okinawa

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Background: Increasing vegetable intake is recommended for promoting health in communities. This study investigated the effects of nutrition education on vegetable intake and the factors associated with changes in vegetable intake among residents of Okinawa.

Methods and Results: Subjects (n=1,345; mean [±SD] age 56.8±14.6 years; 40.5% male) were recruited from among local residents participating in the Yui Kenko Project. Subjects completed the brief-type self-administered diet history questionnaire (BDHQ) and questionnaires on socioeconomic demographics and social capital. Subjects were divided into 2 groups according to residential area, namely south Okinawa (n=679), where local health promotion activities have been undertaken since the early 2000s, and central Okinawa (n=666). Survey results were fed back to each subject, and health lectures were then conducted at local community centers. After 1 year, the BDHQ was repeated to investigate changes in vegetable and nutritional parameters. After the intervention, residents of south Okinawa increased their crude and energy-adjusted vegetable intake ($P<0.05$), whereas residents of central Okinawa showed decreased vegetable intake ($P<0.05$). Univariable and multivariable regression models indicated that, in south Okinawa, participation in local health promotion activities and agreement with general trust were positively correlated with changes in energy-adjusted vegetable intake, whereas in central Okinawa no correlations were observed.

Conclusions: The status of social capital should be taken into account when implementing initiatives to increase vegetable intake in communities.

Key Words: Health promotion; Nutrition education; Social capital; Socioeconomic status; Vegetable consumption

Both salt restriction and increased vegetable intake are recommended lifestyle modifications for the management of hypertension[1] and promoting health in communities.[2] Many studies have demonstrated that people who eat more vegetables are less likely to experience stroke, heart disease, and certain types of cancer.[3] A survey in Japan indicated that vegetable intake has changed little over the past decade, and that only approximately 30% of the population achieves the dietary goal for vegetable intake.[2] Of all the prefectures in Japan, Okinawa has the lowest salt intake, but it also has a relatively low vegetable intake.[4] Therefore, strategies to improve vegetable intake and salt restriction are needed to improve the health status of residents in Okinawa.

Recently, the impact of factors such as age, sex,[5] educational background, and household income,[6–8] as well as the level of social capital,[9,10] which has been recognized as a health determinant, on dietary habits has gained increasing attention. Studies have demonstrated that people with a high level of social capital are more likely to adhere to a healthy diet.[9,10] High levels of trust in society may have favorable effects on health-related behaviors by promoting rapid dissemination of health information, increasing adaptation of healthy norms of behaviors, and inspiring social control over deviant behavior.[11] Therefore, the influence of social capital on nutrition education needs to be determined when attempting to implement healthy eating in a society.

In this study we evaluated the effects of nutrition education on vegetable intake and related nutritional parame-

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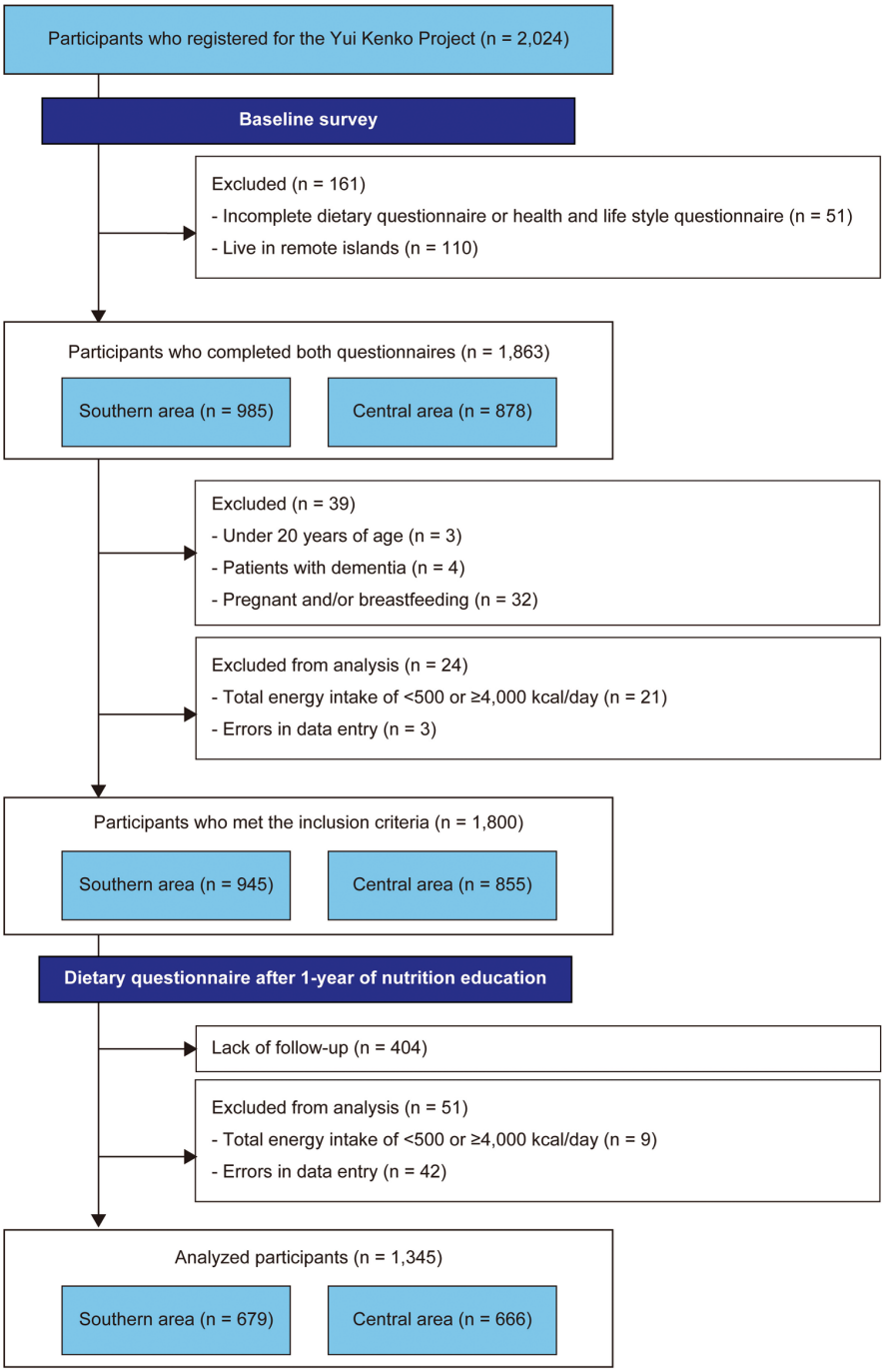

Figure 1. Flow chart for the inclusion of participants in the study.

ters, as well as the impact of social capital on nutrition education to increase vegetable intake among the residents of Okinawa.

Methods

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the University of the Ryukyus (Approval #1445). The protocol and detailed methodology for this study were registered with the University Hospital Medical Information Network (UMIN) Clinical Trials Registry (UMIN000036543).

Participants

The Challenge and New Strategy of Health Promotion for Health and Longevity in Okinawa Residents (Yui Kenko Project) is a health promotion project that uses nutrition education to establish initiatives that contribute to the

prevention of premature death, extension of healthy life expectancy, and promotion of health-related behavioral change in Okinawa. The mission of the Yui Kenko Project is to prevent obesity and to encourage residents to eat more vegetables and reduce their salt intake. Information sessions were held at local community centers to explain the purpose of the project, as well as the schedule for surveys, result briefings, and health lectures.

Local residents who were at least 20 years old were recruited from November 2013 to January 2015. In all, 2,024 participants provided written informed consent and participated in the Yui Kenko Project. Both questionnaires were completed by 1,863 participants, with 1,800 of these participants meeting the inclusion criteria. An additional 455 participants (25.3%) were excluded from the analysis because of a lack of follow-up data (n=404), a total energy intake of <500 or ≥4,000 kcal/day (n=9), and errors in data entry (n=42). The remaining 1,345 participants were included in the present study (**Figure 1**).

According to the administrative division of Okinawa Prefecture, participants from the 6 municipalities were grouped into southern and central areas. In 1 of these municipalities, namely Nanjo City, located in the south, community-based health promotion activities have been in place since the early 2000s.[12] The remaining 5 municipalities are located in central Okinawa. The 6 municipalities and the number of participants were as follows: Nanjo City, n=679; Ginowan City, n=23; Okinawa City, n=39; Uruma City, n=398; Chatan Town, n=181; and Onna Village, n=25.

Nutrition Education

To investigate the food intake of local residents, a dietary

Table 1. Baseline Characteristics

Variable	Total (n=1,345)	Southern area (n=679)	Central area (n=666)	P value
Sex (%)				
Male	40.52	43.74	37.24	0.018
Female	59.48	56.26	62.76	
Age (years)	56.75±14.60	54.38±14.88	59.16±13.91	<0.001
Body mass index (kg/m²)	24.39±3.87	23.81±3.56	24.99±4.08	<0.001
Hypertension (%)				0.14
Yes	26.62	24.74	28.53	
No	61.49	62.00	60.96	
Missing	11.90	13.25	10.51	
Diabetes (%)				0.3
Yes	7.88	7.51	8.26	
No	80.22	79.23	81.23	
Missing	11.90	13.25	10.51	
Year of education (%)				0.007
≤12 years	54.80	50.96	58.71	
≥13 years	42.38	46.54	38.14	
Missing	2.83	2.50	3.15	
Equivalent income based on a median income of 1,837,100 JPY (%)				<0.001
<Median	46.02	41.68	50.45	
≥Median	43.57	50.22	36.79	
Missing	10.41	8.10	12.76	
Living alone (%)				<0.001
Yes	7.96	4.71	11.26	
No	87.14	91.02	83.18	
Missing	4.91	4.27	5.56	
Sports group (%)				<0.001
Yes	27.96	26.51	29.43	
No	65.35	69.81	60.81	
Missing	6.69	3.68	9.76	
Hobby activity (%)				0.004
Yes	30.33	29.16	31.53	
No	63.12	66.27	59.91	
Missing	6.54	4.57	8.56	
Neighborhood association (%)				0.002
Yes	12.79	12.67	12.91	
No	80.07	82.62	77.48	
Missing	7.14	4.71	9.61	

(**Table 1** continued the next page.)

Variable	Total (n=1,345)	Southern area (n=679)	Central area (n=666)	P value
Study or cultural group (%)				<0.001
Yes	9.37	7.22	11.56	
No	82.30	87.04	77.48	
Missing	8.33	5.74	10.96	
Local health promotion activities (%)				<0.001
Yes	11.90	9.43	14.41	
No	80.82	85.57	75.95	
Missing	7.29	5.01	9.61	
Consumer/agricultural cooperative (%)				0.007
Yes	2.38	2.21	2.55	
No	88.92	91.46	86.34	
Missing	8.70	6.33	11.11	
General trust (%)				0.2
Strongly agree/agree	62.01	64.21	59.76	
Other	35.54	33.87	37.24	
Missing	2.45	1.91	3.00	
Norms of reciprocity (%)				0.2
Strongly agree/agree	68.18	70.25	66.07	
Other	29.22	27.54	30.93	
Missing	2.60	2.21	3.00	
Community attachment (%)				
Strongly agree/agree	77.70	78.06	77.33	0.7
Other	20.07	20.03	20.12	
Missing	2.23	1.91	2.55	
Total energy intake (kcal/day)	1,650 [1,330–2,057]	1,700 [1,365–2,148]	1,616 [1,295–2,003]	0.004
Crude values				
Vegetable intake (g/day)	239.49 [161.64–355.18]	246.72 [166.45–364.85]	232.85 [155.69–341.78]	0.025
Dietary fiber (g/day)	10.92 [8.20–14.68]	11.02 [8.45–14.91]	10.85 [7.91–14.38]	0.083
Salt intake (g/day)	9.30 [7.43–11.43]	9.59 [7.53–11.52]	8.95 [7.36–11.36]	0.061
Potassium intake (g/day)	2.27 [1.73–2.98]	2.27 [1.76–3.02]	2.25 [1.69–2.96]	0.2
Sodium-to-potassium ratio	1.65 [1.33–2.04]	1.64 [1.33–2.03]	1.65 [1.33–2.07]	0.7
Energy-adjusted values				
Vegetable intake (g/1,000 kcal)	146.01 [101.48–210.75]	148.81 [103.13–211.76]	145.48 [99.45–205.23]	0.3
Dietary fiber (g/1,000 kcal)	6.62 [5.18–8.27]	6.57 [5.08–8.29]	6.66 [5.27–8.26]	0.6
Salt intake (g/1,000 kcal)	5.64 [4.86–6.48]	5.56 [4.83–6.44]	5.71 [4.95–6.54]	0.048
Potassium intake (g/1,000 kcal)	1.37 [1.08–1.67]	1.35 [1.08–1.67]	1.40 [1.10–1.69]	0.2
Sodium-to-potassium ratio	1.65 [1.33–2.04]	1.64 [1.33–2.03]	1.65 [1.33–2.07]	0.8

Unless indicated otherwise, data are given as the mean±SD or median [interquartile range].

questionnaire, namely the brief-type self-administered diet history questionnaire (BDHQ), was distributed to participants.[13,14] The accuracy of nutrient intake estimated using the BDHQ has been reported previously in a study that compared it with semi-weighted 16-day dietary records.[13,14] Notably, self-reported dietary data have issues such as reporting bias.[15] To compensate for reporting bias in self-reported dietary data, energy-adjusted data for nutritional parameters can be used, with values of consumed nutrition and food in the completed questionnaires calculated as density per 1,000 kcal.[16] Accordingly, energy-adjusted data for nutritional parameters (g/1,000 kcal) were used in the present analysis.

The results of the dietary survey were returned by the project office to each subject, along with a cookbook, to provide nutrition education through a passive information intervention. At the time of registration and in the health lectures, we indicated that the dietary goal for vegetable intake in Japan is 350 g/day.[2] Health lectures were provided to participants at a local community center, explaining the results of the community-wide diet survey and the characteristics of the community. After a period of 1 year, the BDHQ was repeated to investigate changes in food and nutrient intake.

Socioeconomic Factors and Social Capital

To investigate the socioeconomic status and social capital of the participants, a questionnaire was distributed. The indicators of socioeconomic status were years of education, household income, and residential status.[17,18] Years of education were divided into 2 groups: ≤12 and ≥13 years. Household income before taxation was divided into 15 categories (<0.5, 0.5–<1, 1–<1.5, 1.5–<2, 2–<2.5, 2.5–<3, 3–<4, 4–<5, 5–<6, 6–<7, 7–<8, 8–<9, 9–<10, 10–<12, and

Table 2. Changes in Nutritional Parameters in Southern and Central Areas

Variable	Southern area (n=679)			Central area (n=666)		
	Baseline	After intervention	P value	Baseline	After intervention	P value
Total energy intake (kcal/day)	1,700 (1,365–2,148)	1,701 (1,376–2,111)	0.897	1,616 (1,295–2,003)	1,621 (1,282–2,044)	0.882
Crude values						
Vegetable intake (g/day)	246.72 (166.45–364.85)	253.21 (176.20–383.52)	0.009	232.85 (155.69–341.78)	217.85 (141.27–328.77)	<0.001
Dietary fiber (g/day)	11.02 (8.45–14.91)	11.30 (8.48–15.06)	0.106	10.85 (7.91–14.38)	10.63 (7.53–13.93)	0.016
Salt intake (g/day)	9.59 (7.53–11.52)	9.41 (4.82–11.49)	0.809	8.95 (7.36–11.36)	8.78 (4.80–11.70)	0.13
Potassium intake (g/day)	2.27 (1.76–3.02)	2.32 (1.13–3.03)	0.112	2.25 (1.69–2.96)	2.19 (1.10–2.94)	0.394
Sodium-to-potassium ratio	1.64 (1.33–2.03)	1.56 (1.29–1.96)	0.002	1.65 (1.33–2.07)	1.61 (1.35–2.02)	0.129
Energy-adjusted values						
Vegetable intake (g/1,000 kcal)	148.81 (103.13–211.76)	154.31 (108.26–214.85)	0.017	145.48 (99.45–205.23)	134.04 (91.85–191.22)	0.001
Dietary fiber (g/1,000 kcal)	6.57 (5.08–8.29)	6.81 (5.29–8.31)	0.044	6.66 (5.27–8.26)	6.51 (5.09–7.98)	0.021
Salt intake (g/1,000 kcal)	5.56 (4.83–6.44)	5.54 (4.82–6.38)	0.814	5.71 (4.95–6.54)	5.58 (4.80–6.53)	0.062
Potassium intake (g/1,000 kcal)	1.35 (1.08–1.67)	1.39 (1.13–1.71)	0.012	1.40 (1.10–1.69)	1.37 (1.10–1.68)	0.966
Sodium-to-potassium ratio	1.64 (1.33–2.03)	1.56 (1.29–1.96)	0.002	1.65 (1.33–2.07)	1.61 (1.35–2.02)	0.129

Unless indicated otherwise, data are given as the median (interquartile range).

>12 million Japanese yen). To obtain an equivalent income, the median of the household income categories was divided by the square root of the number of household members. Based on the median value of the equivalent income (1.87 million Japanese yen), the household income was divided into 2 groups (below and above the median equivalent income). Residential status was divided into 2 groups: living alone or living with others.

The indicators of social capital were defined as participation in civic activities, general trust, norms of reciprocity, and community attachment.[18] Civic activities included sports- and hobby-related groups, neighborhood associations, study or cultural groups, local health promotion activities, and consumer/agricultural cooperatives. For the item regarding "general trust", subjects were divided into 2 groups: those who answered "very" or "fairly trustworthy" and those who answered "undecided" or "not very or not at all trustworthy" to the question "Do you think people are trustworthy in general?" For the item regarding "norm of reciprocity", subjects were divided into 2 groups: those who answered "very" or "fairly" and those who answered "neither agree nor disagree" or "not much or not at all" to the question "Do you think that people in your community often try to be helpful to others?" For the item regarding "community attachment", subjects were divided into 2 groups: those who answered "very" or "fairly" and those who answered "neither agree nor disagree" or "not much or not at all" to the question "How attached are you to the community in which you live?" If there was no response to a question, it was assigned as "missing".

Outcomes

The primary outcome of interest was the effect of nutrition education on energy-adjusted vegetable intake in each area. Secondary outcomes were correlates associated with changes in energy-adjusted vegetable intake in each area.

Statistical Analysis

Values are expressed as the mean±SD, median with interquartile range (IQR), or as percentages. Unpaired t-tests, Chi-squared tests, Kruskal-Wallis tests, or Wilcoxon's rank-sum tests were used for comparisons of discrete variables between the southern and central areas. Wilcoxon's signed-rank test was used to compare vegetable intake before and after the delivery of nutrition education in each area. Unstandardized and standardized coefficients (β) for changes in energy-adjusted vegetable intake were calculated using univariable and multivariable linear regression models in each area. The independent variables were sex, age, body mass index (BMI), baseline vegetable intake (g/1,000 kcal), socioeconomic status, and social capital. Missing values were categorized as missing. Statistical analyses were performed using R software version 4.0.2 (https://www.R-project.org/). Two-tailed $P<0.05$ was considered statistically significant.

Results

Follow-up Rate and Demographic Characteristics of Participants

The overall follow-up rate of this project was 74.7%. The baseline characteristics of the analyzed and excluded participants are presented in the **Supplementary Table**. Although the mean age of the analyzed group was higher than that of the excluded group, there were no significant differences in other baseline parameters between the 2 groups. We also compared the follow-up rate between the southern and central areas, finding that the follow-up rate was lower for

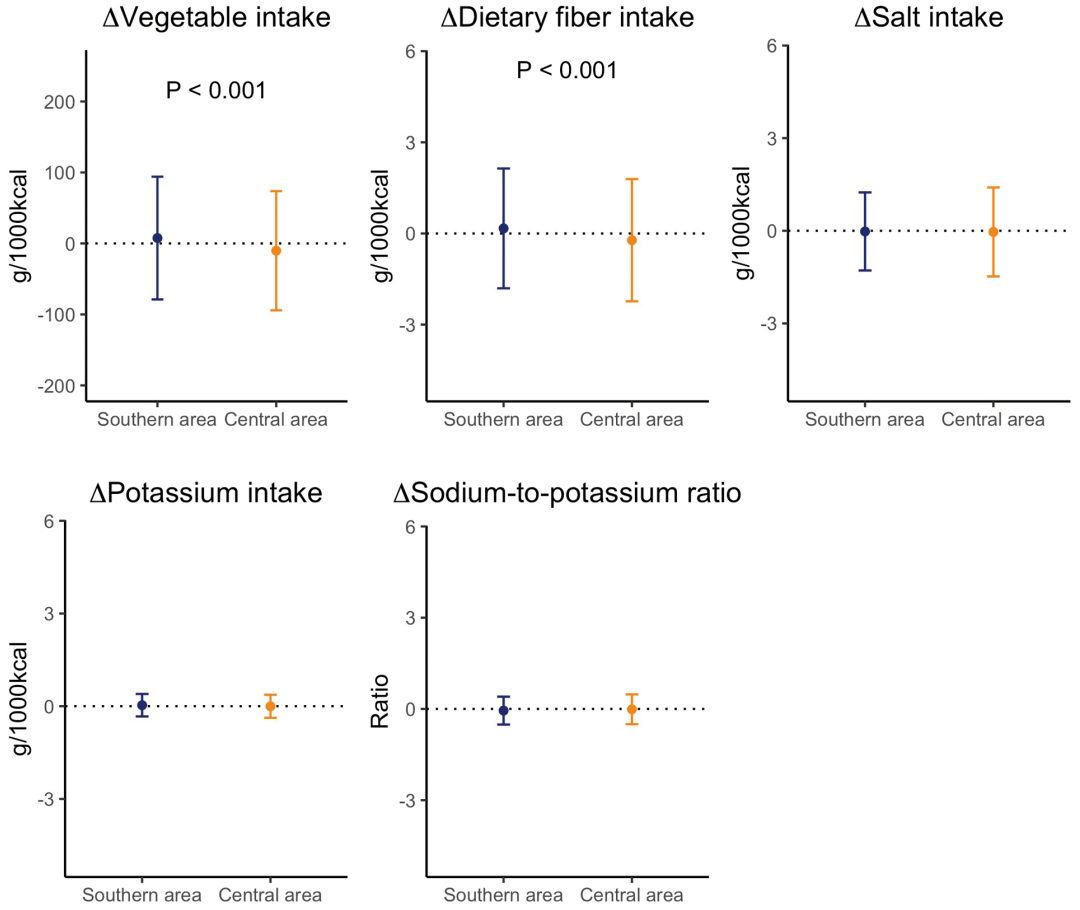

Figure 2. Mean changes in energy-adjusted nutrition parameters between the southern and central Okinawa areas. After nutrition education, the mean (±SD) change in vegetable intake in southern and central Okinawa was 7.60±86.49 and –10.28±83.92 g/1,000 kcal, respectively. The mean change in fiber intake in southern and central Okinawa was 0.17±1.97 and –0.22±2.01 g/1,000 kcal, respectively. The mean changes in vegetable and fiber intake were significantly different between the 2 areas. However, the mean changes in salt intake, potassium intake, and the sodium-to-potassium ratio were comparable between the 2 areas.

the southern than central area (71.9% vs. 77.9%, respectively; P=0.003).

The demographic characteristics of the subjects are summarized in **Table 1**. In south Okinawa, the mean age was 54.38±14.88 years, 43.74% of subjects were male, and the mean BMI was 23.81±3.56 kg/m^2. In central Okinawa, the mean age was 59.16±13.91 years, 37.24% of the subjects were male, and the mean BMI was 24.99±4.08 kg/m^2. The southern region had more male participants, had an average age that was 4.78 years lower, and had a lower BMI (P<0.01) compared with the central region. In addition, the south had a lower percentage of participants with ≤12 years of education, a lower percentage of participants with less than the median equivalent income, and a lower percentage of participants living alone compared with the central region (P<0.01). With regard to the indicators of social capital, the rates of participation in civic activities were higher in the central than southern area (P<0.01). However, no differences were observed between the 2 areas in general trust, norms of reciprocity, and community attachment. With regard to nutritional parameters, the residents of south Okinawa had a higher total energy intake, a higher crude vegetable intake, and a lower energy-adjusted salt intake that the residents of central Okinawa (P<0.05).

In the present study, the self-reported height and weight recorded on the BDHQ were used to evaluate the anthropometric variables. To assess the accuracy of self-reported height, weight, and BMI in an Okinawan sample, we evaluated the validity of self-reported anthropometric variables among the Yui Kenko Project participants. Among all the participants, 780 had available measured values for height, weight, and BMI from a health check-up conducted in the same year that the baseline BDHQ was conducted. There were no significant differences between the measured and self-reported height (157.33±8.25 vs. 157.44±8.14 cm, respectively; P=0.8671), weight (59.71±11.42 vs. 59.80±11.21 kg, respectively; P=0.7935), and BMI (24.08±3.99 vs. 24.07±3.83 kg/m^2, respectively; P=0.9904) values. In addition, Pearson's correlation coefficients between the measured and self-reported values for height (r=0.977, P<0.0001), weight (r=0.968, P<0.0001), and BMI (r=0.966,

P<0.0001) were >0.95. Therefore, the accuracy of self-reported height, weight, and BMI in an Okinawan sample was validated.

Changes in Nutritional and Anthropometric Parameters in Each Area

We investigated the effect of nutrition education on vegetable, fiber, salt, and potassium intake, as well as the sodium-to-potassium ratio, in each area (**Table 2**). In the south, both the crude and energy-adjusted vegetable intake increased significantly after nutrition education, accompanied by a decrease in the sodium-to-potassium ratio; however, there was no decrease in salt intake. In the central area, there were significant decreases in both the crude and energy-adjusted vegetable intake, accompanied by decreases in the crude and energy-adjusted fiber intake; however, there were no changes in the salt and potassium intake or in the sodium-to-potassium ratio.

The mean changes in energy-adjusted nutritional parameters were also compared between the 2 areas. There were significant differences in the mean changes in energy-adjusted vegetable and fiber intake between the 2 areas (**Figure 2**), but no differences in the changes in salt intake, potassium intake, or the sodium-to-potassium ratio. The mean changes in crude vegetable, fiber, and potassium intake also differed significantly between the 2 areas (**Supplementary Figure**). During the follow-up period, there were no significant changes in body weight or BMI in either of the 2 areas (data not shown).

We also conducted an exploratory subgroup analysis of the change in energy-adjusted vegetable intake by socioeconomic status and social capital in each area. In the south, the change in energy-adjusted vegetable intake was significantly higher among subjects who participated in neighborhood associations than among those who did not (28.44±77.91 vs. 3.51±86.17 g/1,000 kcal, respectively; P=0.007). In addition, the change in the energy-adjusted vegetable intake was significantly higher among subjects participated in neighborhood associations than among those who did not (30.46±85.61 vs. 3.60±85.74 g/1,000 kcal, respectively; P=0.02). The change in the energy-adjusted vegetable intake was significantly higher among subjects agreeing with the "general trust" component of the questionnaire than among those who did not (12.62±85.88 vs. −1.57±85.08 g/1,000 kcal, respectively; P=0.042). In the central area, the change in the energy-adjusted vegetable intake was significantly lower among those with ≤12 years of education compared with those with ≥13 years of education (−15.62±88.23 vs. −1.58±78.12 g/1,000 kcal, respectively; P=0.035), whereas the change in the energy-adjusted the vegetable intake was significantly higher among subjects who took part in consumer/agricultural cooperatives than among those who did not (58.14±97.59 vs. −11.53±81.92 g/1,000 kcal, respectively; P=0.01). The other indicators of socioeconomic status and social capital did not affect the change in energy-adjusted vegetable intake in either area (data not shown).

Factors Associated With the Effect of Nutrition Education on Energy-Adjusted Vegetable Intake in Each Area

A univariable linear regression analysis showed that, in south Okinawa, participation in a neighborhood association, participation in local community health promotion activities, agreement with general trust, agreement with norms of reciprocity, and agreement with community attachment were positively correlated with a change in energy-adjusted vegetable intake. The energy-adjusted vegetable intake at baseline was negatively correlated with an increase in energy-adjusted vegetable intake (**Table 3**). In central Okinawa, age, energy-adjusted vegetable intake at baseline, and an educational background of ≤12 years were negatively correlated with a change in energy-adjusted vegetable intake, whereas participation in consumer/agricultural cooperatives was positively correlated with a change in energy-adjusted vegetable intake (**Table 4**).

Multivariable linear regression models showed that, in south Okinawa, participation in local community health promotion activities, agreement with general trust, and participation in hobby activities were positively correlated with a change in energy-adjusted vegetable intake, whereas male sex, energy-adjusted vegetable intake at baseline, and participation in sports-related groups were negatively correlated with a change in energy-adjusted vegetable intake (**Table 3**). In central Okinawa, male sex and energy-adjusted vegetable intake at baseline were negatively correlated with a change in energy-adjusted vegetable intake, whereas the negative correlation between ≤12 years of education and a change in energy-adjusted vegetable intake was not significant (P=0.051). Participation in consumer/agricultural cooperatives was positively associated with a change in energy-adjusted vegetable intake (**Table 4**).

Discussion

Increasing vegetable intake is an important component of a shift towards a healthier and more suitable diet for the prevention of chronic illness. Therefore, the development of effective nutrition education to increase vegetable intake is an important issue. This study investigated the effect of nutrition education on the vegetable intake and nutritional parameters of the residents in Okinawa. There was a regional difference in the effect of nutrition education on nutritional parameters. Nutrition education increased the vegetable intake of residents in south Okinawa, but decreased the vegetable intake of residents in central Okinawa. Univariable and multivariable linear regression models demonstrated that participation in local health promotion activities and agreement with the "general trust" component of the questionnaire were positively associated with a change in the energy-adjusted vegetable intake of residents in the southern but not central area of Okinawa.

Increasing potassium intake and restricting salt intake are recommended lifestyle modifications for patients with hypertension[1] and for implementing health promotion in communities.[2] Suitable vegetable intake, which can result in increases in potassium and fiber intake, appears to be effective for the prevention of non-communicable diseases.[3] However, the rate of achieving recommended levels of vegetable intake is low in Japan.[4] Therefore, initiatives to increase vegetable intake, at both community and national levels, are needed. Various factors, including age, sex, household income, educational background, and social capital, were found to be associated with vegetable intake.[5–9,19,20] Studies have demonstrated that people with a high level of social capital, which has been recognized as a health determinant, are more likely to adhere to a healthy diet, including appropriate vegetable intake.[19] A population-based cross-sectional study of rural areas in Japan revealed significant associations between social capital and the frequency of vegetable intake after adjusting for

Table 3. Linear Regression Model for Changes in Energy-Adjusted Vegetable Intake in the Southern Area

Variable	Univariable model (n=679)			
	Unstandardized β	Standardized β	SE	P value
Male sex	2.491	0.029	6.695	0.710
Age	−0.038	−0.007	0.223	0.865
Body mass index	−0.187	−0.008	0.933	0.842
Vegetable intake at baseline	−0.397	−0.421	0.033	<0.001
Living alone				
Yes	−8.812	−0.022	15.598	0.572
No	Ref.	Ref.	Ref.	
Missing	48.063	0.112	16.347	0.003
Years of education				
≤12	−3.525	−0.020	6.737	0.601
≥13	Ref.	Ref.	Ref.	
Missing	−11.774	−0.021	21.558	0.585
Equivalent income[A]				
<Median	3.163	0.018	6.943	0.649
≥Median	Ref.	Ref.	Ref.	
Missing	25.779	0.081	12.547	0.040
Sports group				
Yes	−2.937	−0.015	7.570	0.698
No	Ref.	Ref.	Ref.	
Missing	26.143	0.057	17.742	0.141
Hobby activity				
Yes	9.039	0.048	7.343	0.219
No	Ref.	Ref.	Ref.	
Missing	43.398	0.105	15.988	0.007
Neighborhood association				
Yes	24.924	0.096	9.977	0.013
No	Ref.	Ref.	Ref.	
Missing	19.624	0.048	15.658	0.211
Study or cultural group				
Yes	15.856	0.047	12.862	0.218
No	Ref.	Ref.	Ref.	
Missing	2.900	0.008	14.304	0.839
Local health promotion activity				
Yes	26.855	0.091	11.335	0.018
No	Ref.	Ref.	Ref.	
Missing	29.145	0.074	15.186	0.055
Consumer/agricultural cooperative				
Yes	−17.391	−0.030	22.611	0.442
No	Ref.	Ref.	Ref.	
Missing	11.098	0.031	13.645	0.416
General trust				
Strongly agree/agree	14.195	0.079	7.037	0.044
Other	Ref.	Ref.	Ref.	
Missing	2.768	0.004	24.618	0.911
Norms of reciprocity				
Strongly agree/agree	15.337	0.081	7.450	0.040
Other	Ref.	Ref.	Ref.	
Missing	6.897	0.012	23.171	0.766
Community attachment				
Strongly agree/agree	16.861	0.081	8.300	0.043
Other	Ref.	Ref.	Ref.	
Missing	17.209	0.027	25.068	0.493

[A]The median income was set at 1,837,100 JPY.

(**Table 3** continued the next page.)

Variable	Multivariable model (n=679)			
	Unstandardized β	Standardized β	SE	P value
Male sex	−21.108	−0.121	6.441	0.001
Age	0.373	0.064	0.238	0.117
Body mass index	−0.422	−0.017	0.857	0.622
Vegetable intake at baseline	−0.446	−0.472	0.035	<0.001
Living alone				
Yes	−20.084	−0.049	14.359	0.162
No	Ref.	Ref.	Ref.	
Missing	39.304	0.092	22.721	0.084
Years of education				
≤12	−3.905	−0.023	6.428	0.544
≥13	Ref.	Ref.	Ref.	
Missing	−46.404	−0.084	22.929	0.043
Equivalent income[A]				
<Median	9.462	0.054	6.432	0.142
≥Median	Ref.	Ref.	Ref.	
Missing	15.188	0.048	16.065	0.345
Sports group				
Yes	−16.200	−0.083	7.583	0.033
No	Ref.	Ref.	Ref.	
Missing	−35.696	−0.078	24.903	0.152
Hobby activity				
Yes	15.731	0.083	7.432	0.035
No	Ref.	Ref.	Ref.	
Missing	75.812	0.183	24.597	0.002
Neighborhood association				
Yes	16.056	0.062	9.955	0.107
No	Ref.	Ref.	Ref.	
Missing	13.465	0.033	25.074	0.591
Study or cultural group				
Yes	1.096	0.003	12.307	0.929
No	Ref.	Ref.	Ref.	
Missing	−41.882	−0.113	24.098	0.083
Local health promotion activity				
Yes	24.474	0.083	12.383	0.049
No	Ref.	Ref.	Ref.	
Missing	39.306	0.099	28.069	0.162
Consumer/agricultural cooperative				
Yes	−23.546	−0.040	20.803	0.258
No	Ref.	Ref.	Ref.	
Missing	−24.077	−0.068	23.212	0.300
General trust				
Strongly agree/agree	16.166	0.090	6.543	0.014
Other	Ref.	Ref.	Ref.	
Missing	−1.070	−0.002	34.128	0.975
Norms of reciprocity				
Strongly agree/agree	−2.240	−0.012	7.499	0.765
Other	Ref.	Ref.	Ref.	
Missing	−27.509	−0.047	36.700	0.454
Community attachment				
Strongly agree/agree	11.116	0.053	8.384	0.185
Other	Ref.	Ref.	Ref.	
Missing	33.646	0.053	38.740	0.385

Table 4. Linear Regression Model for Changes in Energy-Adjusted Vegetable Intake in the Central Area

Variable	Univariable model (n=666)			
	Unstandardized β	Standardized β	SE	P value
Male sex	−2.498	−0.030	6.731	0.711
Age	−0.488	−0.081	0.233	0.037
Body mass index	0.767	0.037	0.797	0.336
Vegetable intake at baseline	−0.471	−0.520	0.030	<0.001
Living alone				
Yes	−5.614	−0.021	10.335	0.587
No	Ref.	Ref.	Ref.	
Missing	−11.007	−0.030	14.263	0.441
Years of education				
≤12	−14.044	−0.082	6.751	0.038
≥13	Ref.	Ref.	Ref.	
Missing	−14.565	−0.030	19.021	0.444
Equivalent income[A]				
<Median	−8.746	−0.052	7.053	0.215
≥Median	Ref.	Ref.	Ref.	
Missing	−2.248	−0.009	10.568	0.832
Sports group				
Yes	1.710	0.009	7.304	0.815
No	Ref.	Ref.	Ref.	
Missing	−13.584	−0.048	11.216	0.226
Hobby activity				
Yes	6.590	0.037	7.159	0.358
No	Ref.	Ref.	Ref.	
Missing	−5.710	−0.019	11.890	0.631
Neighborhood association				
Yes	−9.823	−0.039	9.773	0.315
No	Ref.	Ref.	Ref.	
Missing	−13.840	−0.049	11.120	0.214
Study or cultural group				
Yes	−5.986	−0.023	10.263	0.560
No	Ref.	Ref.	Ref.	
Missing	−7.051	−0.026	10.505	0.502
Local health promotion activity				
Yes	0.939	0.004	9.345	0.920
No	Ref.	Ref.	Ref.	
Missing	−13.919	−0.049	11.137	0.212
Consumer/agricultural cooperative				
Yes	69.669	0.131	20.500	0.001
No	Ref.	Ref.	Ref.	
Missing	−4.751	−0.018	10.288	0.644
General trust				
Strongly agree/agree	−0.137	−0.001	6.800	0.984
Other	Ref.	Ref.	Ref.	
Missing	1.140	0.002	19.537	0.953
Norms of reciprocity				
Strongly agree/agree	−5.667	−0.032	7.092	0.425
Other	Ref.	Ref.	Ref.	
Missing	−5.073	−0.010	19.676	0.797
Community attachment				
Strongly agree/agree	−9.345	−0.047	8.143	0.252
Other	Ref.	Ref.	Ref.	
Missing	−11.534	−0.022	21.61	0.594

[A]The median income was set at 1,837,100 JPY.

(**Table 4** continued the next page.)

Variable	Multivariable model (n=666)			
	Unstandardized β	Standardized β	SE	P value
Male sex	−25.337	−0.146	6.147	<0.001
Age	0.375	0.062	0.232	0.107
Body mass index	0.433	0.021	0.686	0.528
Vegetable intake at baseline	−0.515	−0.568	0.032	<0.001
Living alone				
Yes	−2.949	−0.011	8.900	0.740
No	Ref.	Ref.	Ref.	
Missing	−3.928	−0.011	17.379	0.821
Years of education				
≤12	−12.056	−0.071	6.176	0.051
≥13	Ref.	Ref.	Ref.	
Missing	−43.086	−0.090	20.551	0.036
Equivalent income[A]				
<Median	−12.147	−0.072	6.259	0.053
≥Median	Ref.	Ref.	Ref.	
Missing	−0.021	<0.001	11.631	0.999
Sports group				
Yes	4.978	0.027	6.896	0.471
No	Ref.	Ref.	Ref.	
Missing	−2.835	−0.010	17.733	0.873
Hobby activity				
Yes	7.838	0.043	7.033	0.265
No	Ref.	Ref.	Ref.	
Missing	12.290	0.041	19.365	0.526
Neighborhood association				
Yes	−7.047	−0.028	9.064	0.437
No	Ref.	Ref.	Ref.	
Missing	2.048	0.007	20.993	0.922
Study or cultural group				
Yes	−8.331	−0.032	9.783	0.395
No	Ref.	Ref.	Ref.	
Missing	−2.303	−0.009	18.657	0.902
Local health promotion activity				
Yes	3.733	0.016	9.338	0.689
No	Ref.	Ref.	Ref.	
Missing	−25.110	−0.088	18.478	0.175
Consumer/agricultural cooperative				
Yes	52.565	0.099	17.838	0.003
No	Ref.	Ref.	Ref.	
Missing	8.660	0.032	20.824	0.678
General trust				
Strongly agree/agree	6.473	0.038	6.155	0.293
Other	Ref.	Ref.	Ref.	
Missing	27.798	0.057	26.066	0.287
Norms of reciprocity				
Strongly agree/agree	0.193	0.001	7.009	0.97
Other	Ref.	Ref.	Ref.	
Missing	−9.451	−0.019	42.938	0.826
Community attachment				
Strongly agree/agree	−5.397	−0.027	8.054	0.503
Other	Ref.	Ref.	Ref.	
Missing	−1.907	−0.004	47.578	0.968

sociodemographic variables.[20] In the present study, nutrition education significantly increased the vegetable intake of residents living in south Okinawa, but decreased that of residents in central Okinawa. In the south, the change in energy-adjusted vegetable intake of subjects who took part in neighborhood associations was found to be significantly higher than that of those who did not take part in such activities. Similarly, the change in the energy-adjusted vegetable intake of subjects who took part in local community health promotion activities was significantly higher than that of those who did not; in addition, in the southern region, the change in the energy-adjusted vegetable intake was significantly higher among subjects who reported agreement with general trust than those who did not. However, in the central region, significant associations between these parameters and the energy-adjusted vegetable intake were not observed. Multivariable linear regression models showed that social capital components, such as agreement with local community health promotion activities and agreement with general trust, were positively correlated with the change in energy-adjusted vegetable intake in the south but not in the central region. In the south, community-based health promotion activities have been in place since the early 2000s.[12] These activities may be related to the beneficial effects of nutrition education on vegetable intake in this area.

The method of nutrition education in this study was a document-based passive information intervention using a BDHQ. The amount and timing of the information provided during nutrition education did not have an effect on the increase in the vegetable intake of residents living in central Okinawa. Nutrition education interventions do not always result in increased vegetable intake. Previous studies have demonstrated that nutrition education interventions do not always improve vegetable intake, and sometimes decrease it.[21–23] Recent systematic reviews showed that the efficacy of a nutrition education intervention depends on the duration of the intervention (≥5 months), the number of focused objectives (≤3), the appropriate use of theories, fidelity in interventions, support from policy makers, and management of environmental interventions.[21,22] In the present study, the duration of the intervention was 1 year, 3 objectives were focused on, the fidelity of the intervention was evaluated by research coordinators, and the management of environmental interventions was supported by registered dietitians. However, the type of intervention was not a randomized controlled trial,[24] and the use of theories in nutrition education was not implemented in this study. In addition, the format of the information intervention for this study was not a face-to-face[25] or a web-based approach.[24,26] These factors may have led to an underestimation of the effect of the interventions in this study.

Considering the period for the baseline and follow-up dietary surveys, it is possible that the finding of a decrease in the vegetable intake of the residents living in the central area may reflect general changes in vegetable intake in Japan. According to the latest National Health and Nutrition Survey by the Ministry of Health, Labour and Welfare, the average value of age-adjusted vegetable intake of Japanese residents aged ≥20 years is 269.2 g/day.[2] When viewed over the course of the past 10 years, no significant increase or decrease in vegetable intake has been observed, but there was a slight downward trend. In addition, according to the food supply sheet from the Ministry of Agriculture, Forestry, and Fisheries, the vegetable consumption of Japanese people has followed a decreasing trend year by year; the average net food supply of vegetables per person in the 1990s and 2010s was 286.5 and 247.9 g/day, respectively.[27] Therefore, over the past 30 years, the vegetable consumption per person has decreased by around 40 g/day.

It has been widely reported that vegetable intake remains low among socioeconomically disadvantaged groups, defined by lower household income and lower educational background.[6–8] In the present study we predicted that a lower household income and a lower educational background would be negative determinants of the effects of nutrition education on vegetable intake. In central Okinawa, the univariable linear regression model detected lower education background as a significant negative determinant for energy-adjusted vegetable intake. However, the multivariable linear regression model showed that a lower level of education and a lower household income were not significant negative determinants for the energy-adjusted vegetable intake. The shorter years of education, lower equivalent income, higher proportion of people living alone, and a higher BMI in the central compared with southern area may have interfered with the beneficial effects of nutrition education on vegetable intake. In south Okinawa, there was no clear relationship between socioeconomic status and the effect of nutrition education on energy-adjusted vegetable intake. The reasons for this are unclear, but we cannot rule out the possibility that individuals who were already eating healthily chose to participate in this study. This may have resulted in an underestimation of the relationship between socioeconomic status and vegetable intake.

Future Perspectives

The Japanese government promulgated the Basic Law on Measures Against Stroke, Heart Disease and Other Cardiovascular Diseases to Be Taken for Extending Healthy Lifespan in 2018 (https://www.mhlw.go.jp/web/t_doc?dataId=80ab6708&dataType=0&pageNo=1). Lifestyle modifications including nutrition are one of the core strategies of this basic law. Reasonable and effective nutritional approaches that combine both population and high-risk strategies based on multidisciplinary collaboration are essential for a sustainable, healthy longevity in society, in which the number of cardiovascular diseases is significantly reduced.[1,28] This study provides valuable evidence for the promotion of the implementation of a nutritional approach to prevent and manage non-communicable diseases in society.

Study Limitations

This study had several limitations. The first and most important is that the subjects were not randomly selected local residents in the municipalities, but local residents who wished to participate in the Yui Kenko Project. These participants may not have been representative of the general population in Okinawa. However, in real-world communities, it is realistic to implement health promotion initiatives in a target population that wants to participate in health promotion. Second, the study did not have a control group that did not receive nutrition education intervention. Third, the intervention period of this study was only 1 year. Whether the effectiveness of this nutrition education can be sustained over the long term is an important issue that needs to be examined in the future. Fourth, the overall follow-up rate for this project was not particularly high. In addition, the follow-up rate of the southern

area was lower than that of the central area. Fifth, the dietary survey in this study used the BDHQ, which was based on participants' self-assessments; however, the accuracy of nutrient intake estimated by the BDHQ has been reported.[13,14] Sixth, data regarding socioeconomic factors and social capital were based on the participants' self-assessments, and the answers may have contained some inaccuracies. Seventh, the prevalence of illnesses may influence the effect of nutritional education. However, information regarding the status of clinic/hospital visits and the lifestyle modification guidance received by individual subjects at clinics/hospitals were not available in this dataset. As a result, baseline medical background was not included the linear regression models. Finally, from a public health perspective, it is necessary to examine the relationship between vegetable intake and social capital at the population level.[29] However, due to the limited number of communities in this study, it was not possible to assess the relationship between vegetable consumption and social capital at the population level.

Conclusions

A regional difference was observed for the effect of nutrition education on vegetable intake. In south Okinawa, where local health promotion activities have been in place since the early 2000s,[12] a favorable effect of nutrition education on vegetable intake was observed; however, this was not the case in central Okinawa. Participation in local health promotion activities and agreement with general trust, as indicators of social capital, were positively associated with a change in energy-adjusted vegetable intake in the south, but not in the central region. This study demonstrates that factors related to social capital should be taken into account when implementing initiatives to increase vegetable intake.

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Disclosures

Y.O. is a member of *Circulation Reports*' Editorial Team. The remaining authors have no conflicts of interest to disclose.

IRB Information

This study was approved by the Ethics Committee of the University of the Ryukyus (Approval #1445).

Data Availability

The deidentified participant data will not be shared.

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Supplementary Files

Please find supplementary file(s);
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