

Changes in body weight and food security of adult North Korean refugees living in South Korea

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BACKGROUND/OBJECTIVES: Relocation to new environments can have a negative impact on health by altering body weight and dietary patterns. This study attempted to elucidate changes in body weight, food security, and their current food and nutrient consumption in adult North Korean refugees (NKR) living in South Korea (SK).

SUBJECTS/METHODS: This study analyzed data on 149 adult NKR from a North Korean refugee health in SK cohort at four time points (leaving North Korea, entering SK, first examination, and second examination). Body weight was self-reported at the two earlier time points and directly measured at the two later time points. Food security, diet-related behaviors (dietary habits and food consumption), and sociodemographic information were obtained using a self-administered questionnaire. Nutrient intake information was obtained by one-day 24-hour recall. Statistical analyses were performed with SPSS ver 23.0.

RESULTS: Body weight increased during relocation by an average of 4 kg, although diversified patterns were observed during the settlement period in SK. Approximately 39.6% of subjects maintained their body weight between the first and second examinations, whereas 38.6% gained and 22.1% lost at least 3% of their body weight at the first examination by the second examination. Food security status improved from 12.1% food secure proportion to 61.7%. NKR showed generally good food and nutrient consumption (index of nutrient quality: 0.77-1.93). The body weight loss group showed the most irregular meal consumption pattern ($P < 0.05$), and eating-out was infrequent in all three groups. Consumption frequencies of food groups did not differ by group, except in the fish group ($P = 0.036$).

CONCLUSION: This study observed considerable body weight adjustment during the settlement period in SK after initial weight gain, whereas food security consistently improved. More detailed understanding of this process is needed to assist healthy settlement for NKR in SK.

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INTRODUCTION

The number of North Korean refugees living in South Korea has recently grown to 27,000. There was an increase in North Korean refugees or immigrants entering South Korea after the disastrous food shortage in North Korea in the 1990s [1]. Although the number of North Korean refugees entering South Korea peaked at 2,914 in 2009, the flow remains consistent based on 1,397 North Korean refugees in 2014 [2].

Originally one nation, South and North Korea became two nations after the Korean War from 1950-1953. The people of South and North Korea share the same genetic background but have been exposed to different socio-cultural environments since their division [3]. South Koreans have access to diversified food sources and adequate nutrient intake powered by the economic development of South Korea. Accordingly, the major health problems of South Koreans are diet-related non-communicable diseases such as obesity, diabetes, and hypertension, having

shifted away from the diseases related to undernutrition [4]. In contrast, North Koreans appear to suffer from undernutrition due to economic difficulties caused by the fall of the Soviet economic system and food shortages from continuous natural disasters [5]. Approximately 41.6% of North Koreans were reported as not having consumed sufficient amounts of food in 2015 [6]. Therefore, North Koreans in South Korea may have different nutritional and health status from South Koreans.

Refugees and immigrants face various difficulties and health-related problems such as weight gain in their new environments. Analysis of the U.S. National Health Interview Survey found that the length of residence of immigrants in their new environments was positively and significantly correlated with body mass index (BMI), indicating that early interventions related to diet and physical activity are important in preventing diet-related non-communicable diseases such as obesity among immigrant populations [7]. Analysis of women who immigrated to South Korea through marriage also showed that the proportion of

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underweight women decreased with residence time in South Korea, whereas the proportion of obese women increased [8]. Early analysis of the cohort data in this study found that even a small increase in body weight increased the risk of metabolic syndrome [9]. The Handbook for Workers Supporting North Korean Refugees published by the International Organization for Migration emphasized that North Koreans should be advised to consume a high quality rather than high quantity diet since North Koreans who consume high amounts of foods may be at risk of developing chronic diseases [10].

Currently, only a few studies have examined body weight, health, and nutritional aspects among North Korean refugees in South Korea during the adaptation process. Previously conducted studies have investigated food and nutrient consumption in North Korean refugees while in North Korea [11] as well as food preferences and consumption status [12,13]. One study examined the nutrient consumption status of 12-24 year old North Korean refugees [14], whereas another study compared nutrient consumption status between North Korean child refugees and South Korean children [15]. Few studies have examined food and nutrient intake in adult North Korean refugees. Choe *et al.* [16] reported that North Korean adult refugees who have lived in South Korea for less than 3 years appear to have healthy dietary habits with regular breakfast consumption, sufficient amount vegetable intake, and high-fat food avoidance. This study, however, was limited by the limited number of dietary assessment questions and relatively short length of residence. Therefore, studies are needed that investigate how North Korean refugees experience changes in body weight, food security, and diet during their adjustment in South Korea.

This study attempted to understand 1) changes in body weight and food security among adult North Korean refugees living in South Korea over the course of relocation and 2) current food and nutrient consumption among adult North Korean refugees living in South Korea.

SUBJECTS AND METHODS

Study design and subjects

This study analyzed data from a North Korean refugee health in South Korea (NORN) cohort [17]. This cohort began in October of 2008 by recruiting subjects using the snowball method with assistance from the North Seoul branch of the Hana Center. The Hana Center provides settlement-related support to North Korean refugees. Adult North Korean refugees (age > 19 years) voluntarily participated, responding to the announcement for a health check-up. Subjects completed a health questionnaire and underwent a complete medical check-up. Follow-up of the cohort started in August of 2012 and is currently on-going. Data on 163 subjects who underwent their first examination between October 2008 and November 2013 and second examination between August 2012 and October 2015 were used in this study. Among the 163 subjects, 14 were excluded because of incomplete questionnaires or double participation, resulting a final sample of 149 subjects.

The study protocol was approved by the Korea University Institutional Review Board (No. ED08023).

Measurements

Subjects were asked to complete a 34-item diet and health questionnaire and 63-item food frequency questionnaire. The questionnaires were self-administered and took approximately 20 minutes. Individual diet and nutrition counseling was administered for approximately 15 minutes. Height and weight were measured as a part of the medical check-up that took approximately 1.5 hours. The medical check-up was conducted after fasting for 8 hours or longer.

Body weight changes

Body weight was obtained for four time points: leaving North Korea, entering South Korea, first examination, and second examination. Body weights when leaving North Korea and entering South Korea were self-reported through the diet and health questionnaire.

Additionally, questions on subjective determination of body shape (very thin, thin, normal, fat, and very fat) and body weight changes (no change, weight gain, and weight loss) were also included in the questionnaire. A question on intentional weight changes was included to determine whether or not subjects attempted weight management for weight loss, gain, maintenance, or not at all.

Body weights at the first and second examinations were measured during the medical check-up. BMI calculated based on the measured weight and height was used to group subjects by body weight status into four categories according to World Health Organization & the International Obesity Task Force: Asia [18]: underweight (BMI < 18.5 kg/m²), normal (18.5 ≤ BMI < 23 kg/m²), overweight (23 ≤ BMI < 25 kg/m²), and obese (BMI ≥ 25 kg/m²).

Based on body weight changes from the first to second examinations, subjects were grouped into three categories (body weight gain, body weight maintenance, and body weight loss) to elucidate body weight change patterns during the settlement period in South Korea.

Subjects who gained 3% or more of their body weight at the first examination by the second examination were identified as the "body weight gain" group while subjects who lost 3% or more of their body weight at the first examination by the second examination were identified as the "body weight loss" group. All other subjects with a body weight within the 3% of their body weight at the first examination were identified as the "body weight maintenance" group. This cut-off value of 3% was chosen for this study because the value was determined not only for clinical but also for public health applications, comparability across body sizes, measurement error, normal weight fluctuations, and biologic relevance, whereas other recommendations tended to focus on clinical applications for intentional body weight loss [19].

Food security

Food security was examined using two sets of questions. First, a translated version of household food insecurity access scale (HFIAS), developed by the United States agency for international development and food and nutrition technical assistance was used to determine the household food insecurity status of the subjects in North Korea. HFIAS was developed to assess the

food security status of various international populations [20]. This study used the average score of the scale and four categorizations (food secure, mildly food insecure, moderately food insecure, and severely food insecure). Second, a summary question among food security questions from the Korea National Health and Nutrition Examination Survey (KNHANES) was used to assess and compare food security status during the process of relocation from North Korea to the transient nation (if applicable) and eventually to South Korea. The transient nation indicates any nations that subjects went through on their route to South Korea. The summary question consisted of four response items: "All of my family members were able to eat various foods that we wanted to eat in sufficient amounts," "All of my family members were able to eat food that we wanted in sufficient amounts, but not various kinds," "We were from time to time short of food due to economic difficulty," "We were very often short of food due to economic difficulty [21]."

Diet

Diet was examined only at the second examination. Various aspects of diet were examined: 1) dietary habits, 2) food consumption, and 3) energy and nutrient intake.

Dietary habits included skipping rates of breakfast, lunch, and dinner, proportions of breakfast, lunch, and dinner with family, eating-out frequencies, functional food consumption rates, vitamin & mineral consumption rates, proportions of receiving nutrition education or counseling, and proportions of using food labels. These variables were examined using questions for variables in the KNHANES [21].

Food consumption was examined using a non-quantitative food frequency questionnaire from the 2011 KNHANES. Consumption frequency of 63 foods was asked with nine response categories (3 times per day, once per day, 4-6 times per week, 2-3 times per week, once per week, 2-3 times per month, once per month, 6-11 times per year, and rarely). This study converted responses to average daily consumption frequencies.

Energy and nutrient intake was examined by the one-day 24-hour recall method. Fully trained research assistants conducted face-to-face 24 hour recall interviews after 1 day using various supplementary food models and pictures. CAN-Pro 5.0 (Computer aided nutritional analysis program 5.0 for professionals, Korean Society of Nutrition, Seoul, Korea) [22] was used to convert the food consumption information to nutrient consumption

information. The 2015 Dietary Reference Intakes for Koreans [23] was used to determine energy and nutrient intake status. This study also calculated index of nutrients quality (INQ) to determine dietary quality in terms of nutrient intake independent of amount of food consumed. Finally, odd ratios were obtained for likelihood of under- or over-consumption of energy and nutrients by the body weight change group, adjusting for sex, age, age upon leaving North Korea, length of residing in the transient nation, length of residence in South Korea, income, current occupation, education, and marital status. The length of residence in the transient nation was included since many subjects went through a transient nation, mostly China, before arriving in South Korea, and this may have affected their diet [24].

Covariates

Age, age upon leaving North Korea, time period after leaving North Korea, length of residence in the transient nation, length of residence in South Korea, follow-up time between first and second examinations, residence in North Korea (urban or rural), current monthly income, occupation in North Korea and currently, education, number of co-residents, and marital status. These variables were included since they have been reported to influence body weight, food security, and dietary behavior of refugees and immigrants [7-16]. The variables were self-reported using the diet and health questionnaire.

Statistical analysis

All analyses were conducted with SPSS 23.0 (SPSS Inc., IBM corp., NY, USA). Analysis of continuous variables across the body weight change groups was done with analysis of variance and Tukey's honestly significant difference test. Kruskal-wallis test was used if the equal variance assumption was not met. Categorical variables are presented as frequency and percentage and analyzed with chi-square test, and Fisher's exact test. Multiple logistic regressions were performed to obtain odd ratios adjusting for covariates.

RESULTS

Sociodemographic information

Sociodemographic information of the subjects is presented in Table 1. More women (82.6%) than men participated. The subjects left North Korea at an average age of 37.8 years.

Table 1. Sociodemographic information by body weight change status of adult North Korean refugees in South Korea

	Body weight loss group (n = 33, 22.1%)	Body weight maintenance group (n = 59, 39.6%)	Body weight gain group (n = 57, 38.3%)	Total (n = 149)	P-value
Sex					
Male	8 (24.2) ¹⁾	9 (15.3)	9 (15.8)	26 (17.4)	0.506 ²⁾
Female	25 (75.8)	50 (84.7)	48 (84.2)	123 (82.6)	
Age (yrs)	(n = 33)	(n = 59)	(n = 57)	(n = 149)	
	51.5 ± 12.9 ^{3)a}	50.2 ± 12.6 ^{ab}	45.1 ± 10.3 ^b	48.5 ± 12.1	0.020 ⁴⁾⁵⁾
19-29	1 (3.0)	1 (1.7)	0 (0.0)	2 (1.3)	0.077 ⁶⁾
30-49	15 (45.5)	31 (52.5)	41 (71.9)	87 (58.4)	
50-64	11 (33.3)	17 (28.8)	13 (22.8)	41 (27.5)	
≥ 65	6 (18.2)	10 (16.9)	3 (5.3)	19 (12.8)	
Age upon leaving North Korea (yrs)	(n = 33)	(n = 57)	(n = 55)	(n = 145)	
	40.9 ± 12.7 ^a	39.9 ± 14.4 ^{ab}	33.8 ± 10.8 ^b	37.8 ± 13.0	0.012 ⁴⁾⁵⁾
12-18	0 (0.0)	0 (0.0)	3 (5.5)	3 (2.1)	0.140 ⁶⁾

Table 1. continued

	Body weight loss group (n = 33, 22.1%)	Body weight maintenance group (n = 59, 39.6%)	Body weight gain group (n = 57, 38.3%)	Total (n = 149)	P-value
19-29	8 (24.2)	14 (24.6)	18 (32.7)	40 (27.6)	
30-49	16 (48.5)	31 (54.4)	29 (52.7)	76 (52.4)	
50-64	8 (24.2)	8 (14.0)	5 (9.1)	21 (14.5)	
≥ 65	1 (3.0)	4 (7.0)	0 (0.0)	5 (3.4)	
Time period after leaving North Korea (months) ⁷⁾	(n = 33)	(n = 57)	(n = 55)	(n = 145)	
	128.1 ± 49.9	131.3 ± 48.9	132.9 ± 52.1	131.2 ± 50.0	0.909 ⁵⁾
Length of residence in the 3rd nation (months) ⁸⁾	(n = 33)	(n = 57)	(n = 54)	(n = 144)	
	45.6 ± 43.1	46.2 ± 37.8	54.2 ± 46.9	49.1 ± 42.5	0.535 ⁵⁾
Length of residence in South Korea (months) ⁹⁾	(n = 33)	(n = 58)	(n = 55)	(n = 146)	
	82.5 ± 34.5	84.3 ± 30.8	86.2 ± 72.7	84.6 ± 51.0	0.948 ⁵⁾
Follow-up time between first and second examinations (months) ¹⁰⁾	(n = 33)	(n = 59)	(n = 57)	(n = 149)	
	40.4 ± 7.9	43.1 ± 11.3	40.7 ± 10.9	41.6 ± 10.5	0.369 ⁵⁾
Residence in North Korea	(n = 28)	(n = 49)	(n = 39)	(n = 116)	
Urban	13 (46.4)	36 (73.5)	22 (56.4)	71 (61.2)	0.048 ²⁾
Rural	15 (53.6)	13 (26.5)	17 (43.6)	45 (38.8)	
Occupation in North Korea	(n = 32)	(n = 55)	(n = 53)	(n = 140)	
Manual worker/farmer	19 (59.4)	22 (40.0)	29 (54.7)	70 (50.0)	0.084 ²⁾
Office worker/soldier/teacher/professional	13 (40.6)	23 (41.8)	18 (34.0)	54 (38.6)	
Student/unemployed	0 (0.0)	10 (18.5)	6 (11.3)	16 (11.4)	
Current occupation	(n = 31)	(n = 58)	(n = 55)	(n = 144)	
Full-time worker	3 (9.7)	10 (17.2)	10 (18.2)	23 (16.0)	0.754 ⁶⁾
Temporary worker	4 (12.9)	10 (17.2)	8 (14.5)	22 (15.3)	
The worker for day	4 (12.9)	4 (6.9)	2 (3.6)	10 (6.9)	
Businessperson	1 (3.2)	1 (1.7)	4 (7.3)	6 (4.2)	
Professional	0 (0.0)	1 (1.7)	2 (3.6)	3 (2.1)	
Student/housewife/unemployed	19 (61.3)	32 (55.2)	29 (52.7)	80 (55.6)	
Education	(n = 32)	(n = 58)	(n = 55)	(n = 145)	
Primary school	1 (3.1)	0 (0.0)	0 (0.0)	1 (0.7)	0.152 ⁶⁾
Secondary school	20 (62.5)	27 (46.6)	26 (47.3)	73 (50.3)	
Technical college	1 (3.1)	5 (8.6)	4 (7.3)	10 (6.9)	
College	2 (6.3)	6 (10.3)	14 (25.5)	22 (15.2)	
University	7 (21.9)	18 (31.0)	9 (16.4)	34 (23.4)	
Graduate school	1 (3.1)	2 (3.4)	2 (3.6)	5 (3.4)	
The number of co-residents (n)	(n = 33)	(n = 58)	(n = 55)	(n = 145)	
	2.4 ± 1.28	2.0 ± 1.16	2.0 ± 0.95	2.1 ± 1.12	0.131 ⁵⁾
Monthly household income (10,000 KRW)	(n = 31)	(n = 47)	(n = 49)	(n = 127)	
	112.5 ± 93.67	140.9 ± 105.51	160.5 ± 134.02	141.5 ± 115.51	0.195 ⁵⁾
< 100	17 (54.8)	18 (38.3)	15 (30.6)	50 (39.4)	0.095 ⁶⁾
100-199	10 (32.3)	20 (42.6)	17 (34.7)	47 (37.0)	
200-299	2 (6.5)	4 (8.5)	9 (18.4)	15 (11.8)	
300-399	0 (0.0)	2 (4.3)	7 (14.3)	9 (7.1)	
≥ 400	2 (6.5)	3 (6.4)	1 (2.0)	6 (4.7)	
Marital status	(n = 33)	(n = 58)	(n = 56)	(n = 147)	
Never married	3 (9.1)	5 (8.6)	11 (19.6)	19 (12.9)	0.483 ⁶⁾
Married	14 (42.4)	29 (50.0)	29 (51.8)	72 (49.0)	
Divorced	5 (15.2)	10 (17.2)	7 (12.5)	22 (15.0)	
Separated	3 (9.1)	4 (6.9)	1 (1.8)	8 (5.4)	
Widowed	8 (24.2)	10 (17.2)	8 (14.3)	26 (17.7)	

KRW: Korea won

¹⁾ Frequency (%)²⁾ Chi-square test³⁾ Mean ± SD⁴⁾ Tukey's honestly significant difference test⁵⁾ One-way analysis of variance⁶⁾ Fisher's exact test⁷⁾ Date of second examination - date of leaving North Korea⁸⁾ Date of entry in South Korea - date of leaving North Korea⁹⁾ Date of second examination - date of entry in South Korea¹⁰⁾ Second examination - first examination

Table 2. Anthropometric measurements and weight status perception according to the weight change status over the course of relocation in adult North Korean refugees

	Body weight loss group (n = 33, 22.1%)	Body weight maintenance group (n = 59, 39.6%)	Body weight gain group (n = 57, 38.3%)	Total (n = 149)	P-value
Weight (kg)					
Upon leaving North Korea	(n = 32) 53.7 ± 8.8 ¹⁾	(n = 50) 51.8 ± 7.3	(n = 54) 51.4 ± 8.1	(n = 136) 52.1 ± 8.0	0.407 ²⁾
Upon entering South Korea	(n = 31) 57.5 ± 10.8	(n = 52) 54.1 ± 7.9	(n = 53) 52.6 ± 8.4	(n = 136) 54.3 ± 9.0	0.148 ³⁾
First examination	(n = 33) 60.2 ± 10.7	(n = 59) 54.9 ± 6.2	(n = 57) 53.9 ± 9.5	(n = 149) 55.7 ± 9.0	0.012 ³⁾
Second examination	(n = 33) 56.0 ± 10.3	(n = 59) 54.9 ± 6.2	(n = 57) 58.1 ± 10.2	(n = 149) 56.4 ± 8.9	0.231 ³⁾
Body weight change (kg) ²⁾	-4.2 ± 2.2	0.0 ± 1.0	4.3 ± 2.1	0.7 ± 3.71	<0.001 ³⁾
Body weight change (%) ³⁾	-7.0 ± 3.3	0.0 ± 1.7	8.1 ± 4.03	1.52 ± 6.6	<0.001 ³⁾
Body mass index					
First examination (kg/m ²)	(n = 33) 24.0 ± 3.1 ^a	(n = 59) 22.6 ± 2.3 ^b	(n = 57) 22.0 ± 2.9 ^b	(n = 149) 22.7 ± 2.9	0.006 ^{2,4)}
Underweight	1 (3.0) ⁵⁾	0 (0.0)	7 (12.3)	8 (5.4)	0.016 ⁶⁾
Normal	15 (45.5)	33 (55.9)	29 (50.9)	77 (51.7)	
Overweight	5 (15.2)	17 (28.8)	12 (21.1)	34 (22.8)	
Obese	12 (36.4)	9 (15.3)	9 (15.8)	30 (20.1)	
Second examination (kg/m ²)	(n = 33) 22.3 ± 2.8 ^a	(n = 59) 22.7 ± 2.30 ^{ab}	(n = 57) 23.8 ± 3.2 ^b	(n = 149) 23.0 ± 2.9	0.025 ^{2,4)}
Underweight	1 (3.0)	0 (0.0)	1 (1.8)	2 (1.3)	0.224 ⁶⁾
Normal	20 (60.6)	32 (54.2)	23 (40.4)	75 (50.3)	
Overweight	5 (15.2)	15 (25.4)	13 (22.8)	33 (22.1)	
Obese	7 (21.2)	12 (20.3)	20 (35.1)	39 (26.2)	
Waist circumference (cm)					
First examination	(n = 32) 83.3 ± 9.5	(n = 56) 78.7 ± 7.7	(n = 54) 75.9 ± 8.1	(n = 142) 78.7 ± 8.7	<0.001 ²⁾
Second examination	(n = 33) 79.0 ± 9.0	(n = 53) 79.7 ± 7.2	(n = 52) 81.8 ± 8.2	(n = 138) 80.3 ± 8.1	0.244 ²⁾
Subjective determination of body shape					
Very thin	(n = 33) 1 (3.0)	(n = 59) 5 (8.5)	(n = 57) 3 (5.3)	(n = 149) 9 (6.0)	0.175 ⁶⁾
Thin	7 (21.2)	7 (11.9)	7 (12.3)	21 (14.1)	
Normal	16 (48.5)	32 (54.2)	21 (36.8)	69 (46.3)	
Fat	9 (27.3)	14 (23.7)	20 (35.1)	43 (28.9)	
Very fat	0 (0.0)	1 (1.7)	6 (10.5)	7 (4.7)	
Subjective determination of body weight changes					
No change	(n = 33) 7 (21.2)	(n = 59) 17 (28.8)	(n = 57) 5 (8.8)	(n = 149) 29 (19.5)	<0.001 ⁷⁾
Weight loss	13 (39.4)	13 (22.0)	5 (8.8)	31 (20.8)	
Weight gain	13 (39.4)	29 (49.2)	47 (82.5)	89 (59.7)	
Whether subjects tried weight management					
Weight loss	(n = 33) 16 (48.5)	(n = 59) 17 (28.8)	(n = 57) 31 (54.4)	(n = 149) 64 (43.0)	0.010 ⁷⁾
Weight maintain	9 (27.3)	12 (20.3)	3 (5.3)	24 (16.1)	
Weight gain	3 (9.1)	6 (10.2)	4 (7.0)	13 (8.7)	
No try at all	5 (15.2)	24 (40.7)	19 (33.3)	48 (32.2)	

¹⁾ Mean ± SD²⁾ One-way analysis of variance³⁾ Kruskal-wallis test⁴⁾ Tukey's honestly significant difference test⁵⁾ Frequency (%)⁶⁾ Fisher's exact test⁷⁾ Chi-square test

Subjects lived in the transient nation for an average of 49.1 months before entering South Korea. The average length of residence in South Korea was 84.6 months. Just over one half of subjects used to live in urban areas in North Korea, and half of subjects worked as labor or in agriculture. In South Korea, subjects lived with two family members, 49% of subjects were

married, and more than 70% of subjects earned less than 1,990,000 Korean won a month.

A total of 39.6% of the subjects maintained their body weight within a 3% range (body weight maintenance group), whereas 38.3% gained weight (body weight gain group) and 22.1% lost weight (body weight loss group). The body weight gain group

Table 3. Food security information by the weight change status over the course of relocation in adult North Korean refugees

	Body weight loss group (n = 33, 22.1%)	Body weight maintenance group (n = 59, 39.6%)	Body weight gain group (n = 57, 38.3%)	Total (n = 149)	P-value
Household food insecurity in North Korea	(n = 33)	(n = 57)	(n = 57)	(n = 147)	
HFIAS	11.6 ± 9.2 ¹⁾	10.8 ± 9.2	8.9 ± 8.0	10.2 ± 8.7	0.324 ²⁾
Food secure	8 (24.2) ³⁾	15 (26.3)	11 (19.3)	34 (23.1)	0.335 ⁴⁾
Food insecure					
Mildly	1 (3.0)	1 (1.8)	7 (12.3)	9 (6.1)	
Moderately	4 (12.1)	5 (8.8)	8 (14.0)	17 (11.6)	
Severely	20 (60.6)	36 (63.2)	31 (54.4)	87 (59.2)	
Food security in North Korea	(n = 33)	(n = 59)	(n = 57)	(n = 149)	
Sufficient amount and various kinds of foods	3 (9.1)	8 (13.6)	7 (12.3)	18 (12.1)	0.781 ⁵⁾
Sufficient amount and not various kinds of foods	7 (21.2)	18 (30.5)	18 (31.6)	43 (28.9)	
Sometimes not enough food	12 (36.4)	15 (25.4)	19 (33.3)	46 (60.9)	
Often not enough food	11 (33.3)	18 (30.5)	13 (22.8)	42 (28.2)	
Food security in the transient nation	(n = 33)	(n = 59)	(n = 57)	(n = 149)	
Sufficient amount and various kinds of foods	10 (30.3)	27 (46.6)	33 (57.9)	70 (47.3)	0.131 ⁴⁾
Sufficient amount and not various kinds of foods	12 (36.4)	22 (37.9)	16 (28.1)	50 (33.8)	
Sometimes not enough food	8 (24.2)	5 (8.6)	6 (10.5)	19 (12.8)	
Often not enough food	3 (9.1)	4 (6.9)	2 (3.5)	9 (6.1)	
Food security in South Korea	(n = 33)	(n = 59)	(n = 57)	(n = 149)	
Sufficient amount and various kinds of foods	15 (45.5)	37 (62.7)	40 (70.2)	92 (61.7)	0.020 ⁴⁾
Sufficient amount and not various kinds of foods	11 (33.3)	17 (28.8)	14 (24.6)	42 (28.2)	
Sometimes not enough food	6 (18.2)	2 (3.4)	0 (0.0)	8 (5.4)	
Often not enough food	1 (3.0)	3 (5.1)	3 (5.3)	7 (4.7)	

HFIAS: household food insecurity access scale

¹⁾ Mean ± SD²⁾ One-way analysis of variance³⁾ Frequency (%)⁴⁾ Fisher's exact test⁵⁾ Chi-square test

(45.1 ± 10.28) was significantly younger than the body weight loss group (51.5 ± 12.9) ($P < 0.05$) and left North Korea at a younger age ($P < 0.05$).

Body weight changes

Body weight changes of adult North Korean refugees in South Korea over the course of relocation are shown in Table 2. Subjects' body weights consistently increased after leaving North Korea (52.1 kg ± 8.0) until entering South Korea (54.3 kg ± 9.0). By the first examination, average body weight increased up to 55.7 kg ± 9.0 and further increased to 56.4 kg ± 8.9 by the second examination. Approximately half (50.3%) of subjects were determined to have normal body weight status. The proportion of subjects that identified as obese increased slightly from the first examination (20.1%) to the second examination (26.2%). Subjective determination of body shape found that 46.4% of subjects reported being normal, whereas 33.6% of subjects thought they were either fat or very fat. Over half (59.7%) of subjects reported that they gained weight since relocating to South Korea, whereas 20.8% reported weight loss. A total of 43% of subjects reported having tried to lose weight.

The body weight maintenance group showed minimal body weight changes (0.0 ± 1.0%), whereas the body weight gain group and body weight loss group showed 8.1% and -7.0% changes, respectively. At the first examination, the three groups

had significantly different proportions of subjects classified as underweight, normal, overweight, and obese ($P = 0.016$), whereas no significant associations were detected between the three groups and body weight status at the second examination.

Most (82.5%) of the body weight gain group and 49.2% of the body weight maintenance group reported subjective weight gain, whereas the body weight loss group showed an even split between subjective weight loss (39.4%) and gain (39.4%) ($P < 0.001$). While most of the body weight loss (48.5%) and body weight gain (54.4%) groups reportedly tried to lose weight, most of the body weight maintenance (40.7%) group reported no attempts ($P = 0.01$).

Food security

Food security status while subjects were in North Korea was low (Table 3). Only 23.1% of subjects were identified as "food secure." Among those who were food insecure, most (59.2%) were severely food insecure. No significant group differences were found.

The food security situation assessed by the summary food security question from the KNHANES showed improvement from North Korea through the transient nation to South Korea (Table 3). A total of 12.1% of subjects reported food consumption in sufficient amount and various kinds in North Korea, but this proportion increased to 47.3% in the transient nation as well

Table 4. Dietary behaviors by the weight change status of adult North Korean refugees in South Korea

	Body weight loss group (n = 33, 22.1%)	Body weight maintenance group (n = 59, 39.6%)	Body weight gain group (n = 57, 38.3%)	Total (n = 149)	P-value
Skipping meal rate ¹⁾					
Breakfast	34.8 ²⁾	25.9	46.4	35.8	0.006 ³⁾
Lunch	21.0	6.5	7.0	9.9	0.004 ³⁾
Dinner	12.1	7.0	5.3	7.5	0.235 ³⁾
Proportion of meals with family ⁴⁾	(n = 31)	(n = 53)	(n = 52)	(n = 136)	
Breakfast	10 (32.3) ⁵⁾	22 (41.5)	22 (42.3)	54 (39.7)	0.626 ³⁾
Lunch	10 (32.3)	16 (30.2)	16 (30.8)	42 (30.9)	0.980 ³⁾
Dinner	18 (58.1)	31 (58.5)	36 (69.2)	85 (62.5)	0.443 ³⁾
Eating-out frequency ⁶⁾	(n = 33)	(n = 59)	(n = 57)	(n = 149)	
1-3 times per day	1 (3.0)	4 (6.8)	5 (8.8)	10 (6.7)	0.226 ⁷⁾
1-6 times per week	7 (21.2)	11 (18.6)	7 (12.3)	25 (16.8)	
1-3 times per month	2 (6.1)	11 (18.6)	15 (26.3)	28 (18.8)	
Rarely	23 (69.7)	33 (55.9)	30 (52.6)	86 (57.7)	
Functional food consumption rate ⁸⁾	(n = 33)	(n = 58)	(n = 57)	(n = 148)	
	11 (33.3)	26 (44.8)	25 (43.9)	62 (41.9)	0.525 ³⁾
Vitamin & mineral consumption rate ⁹⁾	(n = 32)	(n = 58)	(n = 57)	(n = 147)	
	11 (34.4)	24 (41.4)	23 (40.4)	58 (39.5)	0.797 ³⁾
Proportion of having nutrition education or counseling ¹⁰⁾	(n = 33)	(n = 59)	(n = 57)	(n = 149)	
	7 (21.2)	6 (10.2)	6 (10.5)	19 (12.8)	0.225 ³⁾
Proportion of using food label	(n = 32)	(n = 59)	(n = 56)	(n = 147)	
Yes	7 (21.9)	17 (28.8)	9 (16.1)	33 (22.4)	0.430 ³⁾
No	4 (12.5)	6 (10.2)	4 (7.1)	14 (9.5)	
Unknowning	21 (65.6)	36 (61.0)	43 (76.8)	100 (68.0)	

¹⁾ Proportion of [the number of people who answer 'no' whether to eat meal (breakfast, lunch, dinner) or not the day before] + [the number of subjects who answer 'no' whether to eat meal (breakfast, lunch, dinner) or not the day before].

²⁾ %: skipping meal rates were calculated from 2-day data, therefore, only average percentages are presented in the table.

³⁾ Chi-square test

⁴⁾ Rate of people generally (more than 4 days per week) eating a meal with their family

⁵⁾ Frequency (%)

⁶⁾ The frequency of people who answer 'How often do you eat out on average within a year?'

⁷⁾ Fisher's exact test

⁸⁾ The rate of people who eat functional food continuously for more than 2 weeks, within 1 year

⁹⁾ The rate of people who eat vitamins & minerals continuously for more than 2 weeks, within 1 year

¹⁰⁾ Proportion of having nutrition education or counseling within 1 year

as to 61.7% in South Korea. No significant group differences in food security between North Korea and the transient nation were found based on the food security question from the KNHANES. However, the body weight loss group appeared to be less food secure in South Korea than the other two groups ($P = 0.02$).

Diet

Dietary habits are presented in Table 4. Breakfast was the most often skipped meal (35.8%). Breakfast and lunch skipping rates were significantly different by group with P values of 0.006 and 0.004, respectively. Dinner was the meal most often eaten with family (62.5%), followed by breakfast (39.7%) and lunch (30.9%). Eating-out was not prevalent with only 57.7% reporting eating-out. Less than half of subjects reported having consumed functional foods (41.9%) and vitamin and mineral supplements (39.5%). A few (12.8%) received nutrition education or counseling, and 68% did not know about food labels.

Table 5 shows food consumption frequencies. Cereals and vegetables were the only food groups consumed more than

three times daily, whereas consumption frequency of hamburgers, pizza, and fried foods was the lowest. The consumption frequency of milk and dairy products was 2.3 times per day. Only fish showed a significantly different consumption frequency between the groups ($P = 0.036$).

Energy and nutrient intake levels are shown in Table 6. A total of 85.2% of subjects reported less energy intake than estimated energy requirements, whereas 40.3% reported less protein intake than estimated average requirement (EAR). More than half (61.1%) of subjects obtained energy from fat within the recommended range of 15-30%. Approximately three quarters (75.8%) of subjects consumed less calcium than EAR. More than half of subjects consumed less vitamin B₂ (54.4%), niacin (54.4%), and vitamin C (59.7%) than EAR. Many subjects (71.8%) consumed more sodium than the recommended level. A total of 16.8% of subjects reported insufficient consumption of energy, calcium, iron, vitamin A, vitamin C, and riboflavin, whereas 12.8% reported excess consumption of energy and fat. Only vitamin B₂ showed statistically significant differences between the three groups ($P = 0.016$).

Table 5. Food consumption frequency¹⁾ by the weight change status of North Korean refugees in South Korea

Food group	Body weight loss group (n = 33, 22.1%)	Body weight maintenance group (n = 59, 39.6%)	Body weight gain group (n = 57, 38.3%)	Total (n = 149)	P-value
Cereals	3.9 ± 1.7 ²⁾	4.1 ± 1.8	3.7 ± 1.7	3.9 ± 1.7	0.475 ³⁾
Pulses, potatoes	3.2 ± 2.7	2.6 ± 2.7	2.8 ± 2.9	2.8 ± 2.7	0.593 ³⁾
Meat, eggs	1.5 ± 1.5	1.4 ± 1.7	1.4 ± 1.7	1.5 ± 1.7	0.959 ³⁾
Fishes	1.0 ± 1.2	0.7 ± 1.0	1.5 ± 2.2	1.1 ± 1.0	0.036 ⁴⁾
Vegetables	3.5 ± 2.7	2.7 ± 2.0	3.5 ± 3.3	3.2 ± 2.7	0.454 ⁴⁾
Seaweeds	2.1 ± 3.5	1.9 ± 2.5	2.4 ± 3.3	2.1 ± 3.0	0.728 ³⁾
Fruits	1.2 ± 1.8	1.3 ± 1.4	1.7 ± 2.0	1.4 ± 1.8	0.236 ⁴⁾
Milk and dairy products	2.5 ± 3.1	2.2 ± 3.0	2.2 ± 3.0	2.3 ± 3.0	0.882 ³⁾
Beverages	2.3 ± 2.6	2.3 ± 2.9	3.1 ± 2.8	2.6 ± 2.8	0.306 ³⁾
Alcoholic liquors	0.3 ± 0.9	0.3 ± 0.6	0.2 ± 0.5	0.3 ± 0.7	0.789 ³⁾
Other (hamburger, pizza, fried food)	0.1 ± 0.2	0.2 ± 0.4	0.2 ± 0.6	0.2 ± 0.5	0.486 ³⁾

¹⁾ Average daily food consumption frequency: calculated by weekly food consumption frequency per response rate/7

Weekly food consumption frequency: 3 times per day (21 times per week), 2 times per day (14 times per week), once per day (7 times per week), 4-6 times per week (5 times per week), 2-3 times per week (2.5 times per week), once per week (once per week), 2-3 times per month (0.58 times per week), once a month (0.23 times per week), 6-11 times per year (0.16 times per week), and rarely (0 times per week)

²⁾ Mean ± SD

³⁾ One-way analysis of variance

⁴⁾ Kruskal-wallis test

Table 6. Energy and nutrients intake levels by the weight change status of adult North Korean refugees in South Korea^{1,2)}

	Body weight loss group (n = 33, 22.1%)	Body weight maintenance group (n = 59, 39.6%)	Body weight gain group (n = 57, 38.3%)	Total (n = 149)	P-value
Energy					
Less than EER	31 (93.9) ³⁾	48 (81.4)	48 (84.2)	127 (85.2)	0.254 ⁴⁾
Over EER	2 (6.1)	11 (18.6)	9 (15.8)	22 (14.8)	
Fat					
Less than 15% ⁵⁾	18 (54.5)	12 (20.3)	15 (26.3)	45 (30.2)	0.012 ⁴⁾
15%-30%	14 (42.4)	41 (69.5)	36 (63.2)	91 (61.1)	
Over 30%	1 (3.0)	6 (10.2)	6 (10.5)	13 (8.7)	
Protein					
Less than EAR	17 (51.5)	18 (30.5)	25 (43.9)	60 (40.3)	0.090 ⁴⁾
EAR-125% RNI	11 (33.3)	18 (30.5)	12 (21.1)	41 (27.5)	
Over 125% RNI	5 (15.2)	23 (39.0)	20 (35.1)	48 (32.2)	
Ca					
Less than EAR	26 (78.8)	39 (66.1)	48 (84.2)	113 (75.8)	0.129 ⁵⁾
EAR-125% RNI	7 (21.2)	18 (30.5)	9 (15.8)	34 (22.8)	
Over 125% RNI	0 (0.0)	2 (3.4)	0 (0.0)	2 (1.3)	
P					
Less than EAR	11 (33.3)	9 (15.3)	14 (24.6)	34 (22.8)	0.338 ⁴⁾
EAR-125% RNI	9 (27.3)	22 (37.3)	16 (28.1)	47 (31.5)	
Over 125% RNI	13 (39.4)	28 (47.5)	27 (47.4)	68 (45.6)	
Fe					
Less than EAR	11 (33.3)	18 (30.5)	20 (35.1)	49 (32.9)	0.940 ⁴⁾
EAR-125% RNI	9 (27.3)	17 (28.8)	18 (31.6)	44 (29.5)	
Over 125% RNI	13 (39.4)	24 (40.7)	19 (33.3)	56 (37.6)	
Vitamin A					
Less than EAR	18 (54.5)	30 (50.8)	30 (52.6)	78 (52.3)	0.749 ⁴⁾
EAR-125% RNI	7 (21.2)	10 (16.9)	14 (24.6)	31 (20.8)	
Over 125% RNI	8 (24.2)	19 (32.2)	13 (22.8)	40 (26.8)	
Vitamin B₁					
Less than EAR	11 (33.3)	14 (23.7)	17 (29.8)	42 (28.2)	0.729 ⁴⁾
EAR-125% RNI	10 (30.3)	15 (25.4)	14 (24.6)	39 (26.2)	
Over 125% RNI	12 (36.4)	30 (50.8)	26 (45.6)	68 (45.6)	

Table 6. continued

	Body weight loss group (n = 33, 22.1%)	Body weight maintenance group (n = 59, 39.6%)	Body weight gain group (n = 57, 38.3%)	Total (n = 149)	P-value
Vitamin B₂					
Less than EAR	25 (75.8)	25 (42.4)	31 (54.4)	31 (54.4)	0.016 ⁴⁾
EAR-125% RNI	7 (21.2)	16 (27.1)	13 (22.8)	13 (22.8)	
Over 125% RNI	1 (3.0)	18 (30.5)	13 (22.8)	13 (22.8)	
Niacin					
Less than EAR	22 (66.7)	27 (45.8)	32 (56.1)	81 (54.4)	0.330 ⁴⁾
EAR-125% RNI	8 (24.2)	20 (33.9)	18 (31.6)	46 (30.9)	
Over 125% RNI	3 (9.1)	12 (20.3)	7 (12.3)	22 (14.8)	
Vitamin C					
Less than EAR	23 (69.7)	31 (52.5)	35 (61.4)	89 (59.7)	0.490 ⁴⁾
EAR-125% RNI	5 (15.2)	11 (18.6)	11 (19.3)	27 (18.1)	
Over 125% RNI	5 (15.2)	17 (28.8)	11 (19.3)	33 (22.1)	
Na ⁶⁾	21 (63.6)	44 (74.6)	42 (73.9)	107 (71.8)	0.494 ⁴⁾
OINC ⁷⁾	9 (27.3)	8 (13.6)	8 (14.0)	25 (16.8)	0.188 ⁴⁾
OCEF ⁸⁾	1 (3.0)	9 (15.3)	9 (15.8)	19 (12.8)	0.165 ⁴⁾

EER, estimated energy requirement; EAR, estimated average requirement; RNI, recommended nutrient intake; OINC, overall insufficient nutrient consumption; OCEF, over consumption of energy and energy fat.

¹⁾ Energy, less than EER; fat, less than acceptable fat distribution ranges; other nutrients, less than estimates average requirements

²⁾ Energy, over EER; fat, more than acceptable fat distribution ranges; other nutrients, over 125% recommended nutrient Intake

³⁾ Frequency (%)

⁴⁾ Chi-square test

⁵⁾ Fisher's exact test

⁶⁾ Intake of sodium is over goal intake (2.0 g/day)

⁷⁾ Energy intake is under 75% EER, and intakes of calcium, iron, vitamin A, vitamin C, and riboflavin are under EAR

⁸⁾ Intake of energy and fat is over 125% EER and adequate range

Table 7. Index of nutrient quality¹⁾ by the weight change status of adult North Korean refugees in South Korea

	Body weight loss group (n = 33, 22.1%)	Body weight maintenance group (n = 59, 39.6%)	Body weight gain group (n = 57, 38.3%)	Total (n = 149)	P-value ²⁾
Protein	1.38 ± 0.42	1.48 ± 0.44	1.51 ± 0.46	1.47 ± 0.44	0.371
Vitamin A	1.26 ± 1.07	1.57 ± 2.53	1.38 ± 1.27	1.43 ± 1.84	0.711
Vitamin B ₁	2.01 ± 1.41	1.90 ± 0.75	1.91 ± 0.71	1.93 ± 0.92	0.843
Vitamin B ₂	1.08 ± 0.42	1.26 ± 0.52	1.26 ± 0.58	1.22 ± 0.53	0.227
Niacin	1.11 ± 0.46	1.07 ± 0.42	1.11 ± 0.55	1.09 ± 0.48	0.894
Vitamin C	1.28 ± 1.02	1.21 ± 1.09	1.44 ± 1.88	1.31 ± 1.43	0.682
Ca	0.81 ± 0.40	0.74 ± 0.40	0.78 ± 0.36	0.77 ± 0.38	0.707
P	1.78 ± 0.49	1.70 ± 0.50	1.80 ± 0.54	1.76 ± 0.51	0.551
Fe	1.80 ± 0.66	1.68 ± 0.89	1.60 ± 0.74	1.67 ± 0.78	0.509

¹⁾ Nutrient intake amount per 1,000 kcal/recommended nutrient intake per 1,000 kcal

²⁾ One-way analysis of variance

³⁾ Mean ± SD

Table 7 shows the index of nutrient quality. All nutrients showed good quality with values over 1 with the exception of calcium (0.77 ± 0.38). No statistically significant differences in the index of nutrient quality were found between the three groups.

Table 8 presents the likelihood of under- or over-consumption by group adjusted for sex, age, age upon leaving North Korea, length of residence in the transient nation, length of residence in South Korea, current monthly income, current occupation, education, and marital status. Statistically significant differences in vitamin B₂ and calcium were detected. The body weight loss group was five times (OR: 5.00, 95% CI: 1.51-16.52) more likely to consume an insufficient amount of vitamin B₂ than the body weight maintenance group. Both the body weight loss and

body weight gain groups were four (OR: 4.04, 95% CI: 1.02-16.00) and six times (OR: 6.03, 95% CI: 1.71-21.27), respectively, more likely to consume an insufficient amount of calcium than the body weight maintenance group. No statistical differences in energy and other nutrient consumption were observed.

DISCUSSION

This study examined changes in body weight and food security status over the course of relocation as well as current dietary behaviors among 149 adult North Korean refugees living in South Korea based on NORN data. This study observed the general trend of increasing body weight from North to South Korea, and various body weight change patterns were found

Table 8. Odds ratio for likelihood of under- or over-consumption of energy and nutrients by body weight change¹⁻³⁾ of adult North Korean refugees in South Korea

		OR	95% CI
Energy (insufficient consumption)	Body weight loss group	2.98	(0.53-16.88)
	Body weight maintenance group		
	Body weight gain group	1.39	(0.36-5.41)
Protein (insufficient consumption)	Body weight loss group	2.22	(0.73-6.80)
	Body weight maintenance group		
	Body weight gain group	2.58	(0.88-7.54)
Vitamin A (insufficient consumption)	Body weight loss group	0.72	(0.23-2.26)
	Body weight maintenance group		
	Body weight gain group	1.36	(0.49-3.82)
Vitamin B ₁ (insufficient consumption)	Body weight loss group	1.51	(0.44-5.22)
	Body weight maintenance group		
	Body weight gain group	2.47	(0.81-7.56)
Vitamin B ₂ (insufficient consumption)	Body weight loss group	5.00	(1.51-16.52)
	Body weight maintenance group		
	Body weight gain group	2.69	(0.97-7.48)
Niacin (insufficient consumption)	Body weight loss group	2.29	(0.77-6.83)
	Body weight maintenance group		
	Body weight gain group	1.63	(0.61-4.34)
Vitamin C (insufficient consumption)	Body weight loss group	2.00	(0.66-6.10)
	Body weight maintenance group		
	Body weight gain group	1.48	(0.57-3.96)
Ca (insufficient consumption)	Body weight loss group	4.04	(1.02-16.00)
	Body weight maintenance group		
	Body weight gain group	6.03	(1.71-21.27)
P (insufficient consumption)	Body weight loss group	3.04	(0.86-10.79)
	Body weight maintenance group		
	Body weight gain group	2.43	(0.71-8.30)
Fe (insufficient consumption)	Body weight loss group	1.77	(0.54-5.79)
	Body weight maintenance group		
	Body weight gain group	0.92	(0.32-2.61)
Na ⁴⁾ (over consumption)	Body weight loss group	0.61	(0.19-2.02)
	Body weight maintenance group		
	Body weight gain group	1.07	(0.33-3.47)
OINC ⁵⁾ (insufficient consumption)	Body weight loss group	3.02	(0.81-11.29)
	Body weight maintenance group		
	Body weight gain group	0.72	(0.19-2.79)
OCEF ⁶⁾ (over consumption)	Body weight loss group	0.20	(0.02-2.01)
	Body weight maintenance group		
	Body weight gain group	0.85	(0.20-3.55)

OR, odds ratio; CI, confidence interval; OINC, overall insufficient nutrient consumption; OCEF, over consumption of energy and energy fat.

¹⁾ Multinomial logistic regression

²⁾ Dependent variable: energy and nutrients intake [reference: individuals who consumed over estimated energy requirement (EER) or estimated average requirement (EAR)], independent variable: body weight changes (reference: body weight maintenance group)

³⁾ Covariates: sex, age, age upon leaving North Korea, length of residence in the 3rd nation, length of residence in South Korea, current monthly income, current occupation, education, and marital status

⁴⁾ Individuals who consumed over intake goal (2,0 g)

⁵⁾ Intake of energy is under 75% EER, and intakes of calcium, iron, vitamin A, and riboflavin are under EAR. Reference: not OINC

⁶⁾ Intake of energy and fat is over 125% EER and in adequate range. Reference: not OCEF

during the settlement in South Korea. During the approximately 3.5 years between the first and second examinations, 39.6% of subjects maintained their body weight while 38.6% and 22.1% gained and lost over 3% of their body weight at the first examination, respectively. The proportion of food secure subjects increased from 12.1% in North Korea to 61.7% in South Korea. Subjects reported skipping breakfast (35.8%) and rarely eating out (57.7%). Cereals and vegetables were the most frequently consumed food groups. Energy and calcium consumption was somewhat lower compared to Korean. Reference Dietary Intakes, although dietary quality based on INQ was generally appropriate with the exception of calcium.

Relocation to a society with an affluent food environment has been linked to increased body weight [7,25-27], and this study obtained similar results. Adult North Korean refugees, on average, reported a body weight increase from North Korea to South Korea. In addition, this study attempted to examine body weight change patterns while adult North Korean refugees settled in South Korea. While average body weight showed a general increase, various body weight change patterns were observed. This study determined body weight gain (38.3%), maintenance (39.6%), and body weight loss (22.1%).

Among the three body weight change groups, the body weight loss group seems worthy of attention. This smallest yet diverse group was the heaviest until the first examination. It seems that weight loss took place through active engagement in some kind of weight management. This group was also significantly less food secure than the other two groups, but only a few significant differences in food and nutrient intake were found. Weight gain in this cohort was associated with metabolic syndrome [9], but the health impact of weight loss is not clear at this time. Further investigation of this body weight loss group may reveal useful information for health intervention strategies.

A previous study [28] reported that North Korean refugees suffer from poor physical and mental health due to daily instability, indicating food security in the transient nation was also poor. This study, however, found consistent improvement of food security status among adult North Korean refugees from North Korea to the transient nation and finally South Korea. A similar finding was reported in a study on North Korean refugee mothers with young children [29]. North Korean refugees may have to undergo a meaningful dietary adaptation process during their stay in the transient nation offering a better food environment than North Korea, which would have an impact on the dietary adaptation process in South Korea. While this study population showed relatively good food and nutrient intake, more information on the dietary adaptation process in the transient nation would be useful to understand the dietary adaptation process and to develop appropriate nutrition education and counseling programs.

This study has several limitations. Random sampling of subjects was not possible since the list of North Koreans living in South Korea is classified and unavailable for security reasons. Therefore, this study had to resort to the convenience sampling method. The sample size of 149 may not provide sufficient statistical power for all statistical analyses performed in this study, however the observed statistically significant findings

indicates the statistical power was sufficient for some analyses. Even though significant effort was invested to recruit subjects, the unique characteristics of North Korean refugees made recruitment difficult. While body weights at the first and second examinations were measured by trained staff, body weights upon leaving North Korea and entering South Korea were self-reported. North Koreans are required to go through a complete physical examination before they are allowed to enter South Korean society.

Height and weight are measured during the physical examination, which allows North Koreans to learn their body weight upon entering South Korea. Possible recall bias may not be completely removed but could be minimized by the complete physical examination.

Dietary information was only collected at the second examination, which made it difficult to examine longitudinal associations between dietary changes and body weight changes. It was not possible to conduct dietary assessment at the first examination. The 24-hour recall method was conducted for one day. Conducting multiple day 24-hour recall was not possible due to financial and logistic difficulties. However, every possible effort, such as staff training and multiple visual aids, was made to improve the quality of the 24-hour recalls. Although the 24-hour recall data could be used to examine food group consumption, a food frequency questionnaire was also used to obtain usual food group consumption data that would be difficult to get from one-day 24-hour recall data.

This study is one of the first to report changes in body weight and food security of adult North Korean refugees since they left North Korea. The strength of this study is its meaningfully long time period. This study examined subjects who left North Korea an average of longer than 10 years ago and had lived in South Korea for approximately 7 years. The follow-up time between the first and second examinations was 3.4 years. These time periods are longer than those of previous studies [14-16,29]. In addition, use of measured body weight, albeit only at the first and second examinations, is an important strength.

This study carefully examined changes in body weight and food security status among adult North Korean refugees. A large cohort study collecting dietary information at several time points along with body weight and other health information would be needed to further understand the relationships between adaptation, diet, body weight, and health.

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