



Characteristics of Body Composition and Muscle Strength of North Korean Refugees during South Korean Stay

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Background: The aim of this study was to investigate the changes of body composition and muscle strength of North Korean refugees (NKR) according to their duration of stay in South Korea.

Methods: NKR who volunteered and were living in South Korea, aged 20 to 75 years were recruited. Body compositions were analyzed by bioelectrical impedance analysis. Muscle strength was measured with the hand grip test. Demographic and migration information was obtained with a questionnaire.

Results: A total of 158 volunteers were recruited at a mean age of 48.3 ± 11.4 years. The mean time from when they escaped from North Korea and arrived in South Korea was 5.8 ± 4.3 years. Height, weight, and body surface area were significantly smaller in all NKR compared to South Korean controls, except for women aged over 50 years. In females of younger ages (<50 years), NKR with more than a 4-year stay in South Korea had a higher weight and fat mass than that of those who had a shorter stay (less than 4 years) in South Korea. All NKR had a weaker grip strength than that of the age-matched controls from South Korea.

Conclusion: The NKR showed relatively smaller physiques and weaker muscle strength than that of the South Korean controls. In younger female NKR, shorter South Korean stay group showed small body weight and fat mass than that of longer South Korean stay group. Specific health support programs might be needed.

Keywords: North Korean refugees; Body composition; Muscle strength

INTRODUCTION

After the armistice agreement of the Korean War, North and South Korea were divided into two different governments and have different socio-economic environments. Especially from the 1980s, a significant gap in the economy gradually developed, and North Korea has suffered from absolute poverty and famine because of natural disaster and the economic failure of communism [1]. From 1998, a robust exodus began and has in-

creased ever since. North Korean refugees (NKR) enter into China, and many of them wish to settle in South Korea permanently. Indeed, the number of NKR that have entered into South Korea has gradually increased from 1,400 in 2000 to 23,000 in 2012 [2], and their settlement has brought about important issues in South Korean society from many different aspects including the medical field.

Currently, many studies have been conducted focusing on the mental health of NKR. In association with the stressful

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conditions during the defection and resettlement, NKR are susceptible to depression, post-traumatic stress disorder or other psychological disorders [3-8]. In addition, NKRs generally have small and thin physiques because of nutritional deficiency during adolescence and are vulnerable to infectious diseases such as helminthic [9] or tuberculosis infections [10]. However, there are still issues not resolved such as the general health of NKRs and how their health changes after settling in South Korea. The aim of this study was to investigate these issues.

METHODS

Subjects

A case-control study was designed prospectively to compare the body composition between NKRs and South Koreans. Cases consisted of NKR volunteers recruited through the welfare center at the National Medical Center (Seoul, Korea) and their controls included healthy examinees (non-NKRs) who visited the Health care center of the National Medical Center between September 2013 and November 2013. One hundred and fifty-eight NKR volunteers were matched for age (within 3 years) and sex (male vs. female) with 474 healthy non-NKR examinees (ratio, 1:3). Subjects with psychological problems or mental retardations were excluded. Additionally, subjects who had medical history of metabolic syndrome-related diseases (diabetes, hypertension, dyslipidemia, or cardiovascular disease) or cancers were excluded. All the participants provided written informed consent and the Institutional Review Board of the National Medical Center approved this study (H-1307-032-003).

Demographics and migration information

General sociodemographic information were obtained which included age, sex, occupation, and academic level. Migration-related factors such as duration of stay in South Korea or a third country were also obtained with a questionnaire.

Anthropometric measurements

Height and weight were measured using Automatic Height/Weight Measurement System (GL-150, G-Tech International, Seoul, Korea). Body mass index and body surface area were calculated from the measured height and weight. Participants wearing light clothing without socks performed bioelectrical impedance analysis (Inbody720, Biospace, Seoul, Korea), and the analyses of body muscle mass, fat mass, and waist hip ratio were conducted.

Measurement of muscle strength

Hand grip strength was measured with an electronic hand dynamometer (Lavisen, Namyangju, Korea). Subjects were seated with an adducted and neutrally rotated shoulder, a 90° flexed elbow with a neutrally positioned forearm, 0° to 30° flexed wrists, and an ulnar with a deviation of 0° to 30° [11]. Each test was performed three consecutive times at 1-minute intervals to minimize measurement errors due to fatigue [12]. Normative measurement of grip strength from Korean population was used as control [13].

Statistical analysis

Student *t* test, analysis of variance with *post hoc* test, and correlation analysis were performed with SPSS version 21 (IBM Co., Armonk, NY, USA). *P* values <0.05 were considered significant.

RESULTS

Sociodemographic characteristics of the North Korean refugees

Table 1 shows the demographic characteristics of the NKR participants. Among the 158 participants, 133 were women, and their mean age was 48.3±11.4 years. The median entrance year

Table 1. Demographic Characteristics

Characteristic	No. (%)
Sex	
Male	25 (16)
Female	133 (84)
Age, yr	
20–39	34 (22)
40–59	102 (65)
≥60	22 (14)
Duration of stay in South Korea	
Mean±SD	4.1±3.1
≤5	110 (70)
>5	48 (30)
Duration of stay in 3rd country	
Mean±SD	5.8±4.3
Direct entry	54 (34)
≤5	79 (50)
>5	25 (16)
Occupation in South Korea	
No	110 (70)
Yes	48 (30)
Academic level in North Korea	
Middle-high school	99 (63)
College	59 (37)

into South Korea was 2010 (2000 to 2013), and their mean duration of stay in a third country and South Korea were 4.1 ± 3.1 and 5.8 ± 4.3 years, respectively. Seventy percent of the NKR stayed in South Korea for more than 5 years, and 30% had an occupation in South Korea.

Comparisons of body composition between North Korean refugees and South Korean controls

In the male group, all NKR groups showed significantly smaller values for height, weight, muscle mass, body mass index, body surface area, and waist hip ratio than those of the age- and sex-matched South Korea controls (Table 2). Female NKRs

and their age- and sex-matched South Korean controls showed similar differences of body compositions as males, except for the body mass index (Table 2).

In females, the NKR female participants were further divided into four groups according to their median duration of stay in South Korea (less than 4 years, NKR <4; more than 4 years, NKR ≥ 4) and the age. Since menopausal status is one of the major factors affecting to the body composition, female participants were divided according to their age, young (age <50) and old (age ≥ 50). Body composition indexes were first compared between three groups in each age group: South Korean controls, NKR <4 group and NKR ≥ 4 group. In young female group,

Table 2. Comparisons of Body Composition between North Korean Refugees and South Korean Controls

Variable	Male			Female		
	North Korean refugees	South Korean	P value	North Korean refugees	South Korean	P value
Number	25	75		25	75	
Age, yr	48.2 ± 14.4	48.2 ± 14.6	1.000	48.3 ± 10.8	48.1 ± 11.2	0.924
Height, cm	155.9 ± 6.4	171.3 ± 7.1	<0.001	157.1 ± 6.1	158.8 ± 5.5	0.005
Weight, kg	54.9 ± 6.6	73.8 ± 13.8	<0.001	56.6 ± 8.3	58.8 ± 8.4	0.010
Muscle mass, kg	20.7 ± 3.4	31.5 ± 4.8	<0.001	21.4 ± 3.7	21.5 ± 2.6	0.737
Body fat mass, kg	16.4 ± 5.4	17.8 ± 7.8	0.340	17.2 ± 5.7	18.9 ± 6.0	0.003
Body mass index, kg/m ²	22.9 ± 3.1	25.1 ± 3.9	0.007	22.9 ± 2.8	23.4 ± 3.2	0.146
Body surface area, m ²	1.54 ± 0.11	1.86 ± 0.19	<0.001	1.56 ± 0.19	1.61 ± 0.12	0.001
Waist hip ratio	0.84 ± 0.04	0.90 ± 0.07	<0.001	0.86 ± 0.05	0.87 ± 0.09	0.024

Values are expressed as mean \pm SD.

Table 3. Comparisons of Body Composition between Female North Korean Refugees and Female South Korean Controls

Variable	Young (ages <50)			P value from ANOVA	Old (ages ≥ 50)			P value from ANOVA
	North Korean refugees		South Korean		North Korean refugees		South Korean	
	<4 yr ^a	≥ 4 yr ^a			<4 yr ^a	≥ 4 yr ^a		
Number	45	30	191		26	31	171	
Age, yr	40.1 ± 7.8	42.2 ± 4.3	39.6 ± 6.8	0.145	57.3 ± 6.6	58.5 ± 6.9	57.6 ± 6.3	0.763
Height, cm	156.4 ± 6.7^b	157.2 ± 5.7^b	160.5 ± 5.2	<0.001	157.4 ± 6.2	157.9 ± 5.6	156.8 ± 5.2	0.544
Weight, kg	55.2 ± 8.4^b	57.9 ± 8.8^c	59.1 ± 8.9	0.031	57.3 ± 9.3	57.0 ± 6.7	58.6 ± 7.7	0.459
Muscle mass, kg	21.2 ± 3.7	21.2 ± 3.7	21.9 ± 2.6	0.179	21.3 ± 3.8	21.9 ± 3.6	21.0 ± 2.6	0.256
Fat mass, kg	16.0 ± 5.2^b	18.6 ± 5.5^c	18.5 ± 6.4	0.048	17.9 ± 6.1^b	16.7 ± 6.1^b	19.4 ± 5.5	0.032
Body mass index, kg/m ²	22.5 ± 2.6	23.4 ± 3.0	23.0 ± 3.6	0.530	23.0 ± 2.8	22.9 ± 2.8	23.8 ± 2.8	0.132
Body surface area, m ²	1.5 ± 0.1^b	1.5 ± 0.3^b	1.6 ± 0.1	0.002	1.6 ± 0.2	1.6 ± 0.1	1.6 ± 0.1	0.683
Waist hip ratio	0.85 ± 0.05	0.86 ± 0.05	0.87 ± 0.06	0.089	0.86 ± 0.05	0.85 ± 0.04	0.88 ± 0.11	0.323

Values are expressed as mean \pm SD.

ANOVA, analysis of variance.

^aDuration of stay in South Korea; ^b $P < 0.05$, the difference between each North Korean refugee (NKR) group and the South Korean controls; ^c $P < 0.05$, the difference between the NKR <4 years and NKR ≥ 4 years groups.

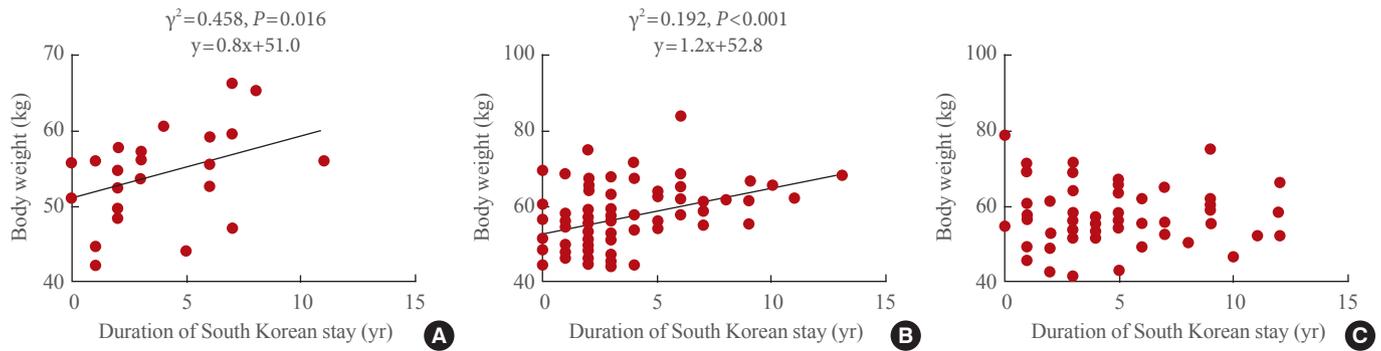


Fig. 1. Correlations between the duration of stay in South Korea and body weight North Korean refugees according to their age and sex. (A) Male, (B) female under 50 years old, and (C) female over 50 years old.

Table 4. Comparisons of the Mean Hand Grip Strength between North Korean Refugees and South Korean Controls

	Age, yr	North Korean refugees		South Korean controls ^a		P value ^b	P value ^c		
		No.	Right, kg	Left, kg	No.			Right, kg	Left, kg
Male	20–79	25	33.2±10.1	33.7±8.9	33	43.0±11.4	42.5±10.7	0.001	0.001
Female	20–49	76	19.4±6.6	18.0±5.7	123	27.3±4.2	25.6±4.3	<0.001	<0.001
	50–79	57	19.0±5.3	18.1±4.6	52	25.1±5.0	23.5±5.2	<0.001	<0.001

Values are expressed as mean±SD.

^aData from a normal South Korean population [11]; ^{b,c}P values are from the compare between North Korean refugees and South Korean controls in both right and left, respectively.

height and body surface area were significantly smaller in both NKR <4 group and NKR ≥4 group than that of the South Korean controls (Table 3). Interestingly, in this age group, the NKR ≥4 group showed significantly higher weight and body fat mass than that of the NKR <4 group, which were comparable to that of the South Korean controls (Table 3). In old female group, all body composition parameters showed no difference between the three groups except for the body fat mass.

Next, correlations of body composition indexes and the duration of stay in South Korea were studied. Interestingly, body weight showed positive correlations with the duration of stay in South Korea in male ($\beta=0.814$, $\gamma^2=0.458$, $P=0.016$) (Fig. 1A) and young female ($\beta=1.220$, $\gamma^2=0.192$, $P<0.001$) (Fig. 1B) groups, but not in the old female groups (Fig. 1C). Correlations between muscle mass and the duration of stay in South Korea was analyzed adjusting age, since age showed strong correlations with muscle mass in each gender (male: $\beta=-0.274$, $\gamma^2=0.075$, $P=0.006$; female: $\beta=-0.144$, $\gamma^2=0.021$, $P=0.001$). As a result, muscle mass showed no significant correlations with the duration of stay in South Korea, neither male nor female.

Comparisons of mean hand grip strength between North Korean refugees and South Korean controls

Next, to measure muscle quality, hand grip strength was measured in all the NKR and compared with the published data from a normal South Korean population [11]. NKR participants showed markedly lower strength in both male and female NKR than normal South Korean population (Table 4). Meanwhile, there were no significant correlations between muscle strength and the duration of stay in South Korea in both genders.

DISCUSSION

In the present study, height, weight, and body surface area were significantly smaller in all NKR than that of the South Korean controls, except for females aged over 50 years. In females, young NKR participants with more than a 4-year stay in South Korea had higher weight and fat mass than those with a shorter duration in South Korea (less than 4 years). All NKR had a weaker grip strength than that of the South Korean controls. Taken together, the NKR had relatively lean body compositions and weak muscle strength than that of the South Korean controls.

Consistent with other studies [14–16], the NKR showed

small physiques than that of the South Korean controls. The mean body height, weight, body surface area, and waist hip ratio were smaller in NKR than that of South Korean controls in both male and female. The discriminative factors of body composition were different between their genders: NKR men had smaller muscle mass while women had smaller fat mass than that of the South Korean controls.

More interestingly, young female NKRs showed differences body compositions according to their durations of South Korean stay. Body weight and fat mass were significantly higher in NKR ≥ 4 group than that of the NKR < 4 group, which were comparable to that of the South Korean women. Additionally, young female NKRs showed positive correlations between body weight and their duration of stay in South Korea, while NKR over 50 years of age showed no correlation. One of the possible explanations is that young NKRs have been suffering from extreme starvation in their childhood because of the natural disaster and economic collapse of North Korea since the 1970s. These might resulted in the bigger differences of body compositions between young and elders female NKRs, especially who has a shorter duration of the South Korea stay. Interestingly, the difference in body composition was much less in young female NKRs who stayed in South Korea more than 4 years. The present study is hard to clarify the impacts of the duration of South Korean stay on body composition, because of the limitations of a cross-sectional design. Further study is need to verify whether younger NKRs were more susceptible to environmental changes or not.

Although our data have the limitations of a small-sized, cross-sectional observation study, we were able to gain some insights. Because NKRs, especially those underwent absolute malnutrition in their early lives, have frail physiques, an increase in body fat and muscle mass after re-settlement in South Korea might be beneficial to their general health. Still, there are also some concerns about it. According to the thrifty phenotype hypothesis, the experience of nutritional insufficiency drives the whole body metabolism to energy storage phenotypes [17]. In later life with sufficient nutrition, these subjects have increased susceptibility to altered metabolism, such as diabetes, hypertension, stroke, or coronary heart disease [18]. Similarly, sudden exposure to excess foods could cause serious metabolic alterations especially in younger NKRs who underwent extreme severe malnutrition in their childhood or infancy. Thus, especially for younger NKRs, a well-designed nutritional program might be needed to improve their health conditions.

Another interesting finding in this study was that the weak

muscle strength of NKRs was quantified with the grip strength measurement. NKRs had a weaker grip strength for both genders, and the mean grip strength of women was close to meeting the criteria of sarcopenia [19]. Different from other body compositions, there was no difference in grip strength between the different groups for the duration of stays in South Korea. Sarcopenia and sarcopenic obesity, which have increased in South Korean elderly, are currently well-established risk factors for cardiometabolic diseases including diabetes and coronary heart disease [20-22]. Related to the findings that younger female NKRs with longer South Korean stay and elder female NKRs had a similar body weight and fat mass to that of South Koreans, weaker muscle strength could cause serious alterations in whole body metabolisms including glucose intolerance or metabolic syndrome. There is on-going cohort study, named North Korean refugee health in South Korea [23]. A total of 440 NKRs were initially recruited and medical examination, including anthropometric measurements and biochemical analyses, will be followed after 3.5 years from initial recruitment. Up-coming data form this cohort would provide valuable information to unsolved questions in the present study.

In this study, body composition analyses has been performed using bioelectrical impedance analysis method, which calculates total body water, body fat, body weight, and fat-free body mass by measuring electrical impedance through whole body tissues [24]. Although it is simple and easy to access in clinics, the results is not as accurate as dual X-ray absorptiometry, since it estimated body composition indirectly [25]. Further validation study using more accurate method such as dual X-ray absorptiometry or computed tomography is needed.

In conclusion, body composition analyses showed that NKRs have a relatively poor health status. Environmental changes after resettlement in South Korea might have bidirectional impacts on the health conditions of NKRs, both beneficial and harmful. A specific health support program is need based on their age and gender.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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