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REGULAR ARTICLE

Relationship between the degree of property damage and changes in red blood cells, hematocrit, and hemoglobin among victims of the Noto Peninsula Earthquake

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Abstract
Objectives The aim of this study was to assess the impact of the Noto Peninsula Earthquake on various hematologic parameters. We studied the relationships between the degree of property damage and changes in red blood cells (RBCs), hemoglobin (Hb), and hematocrit (Ht) among residents before and after the March 2007 Noto Peninsula Earthquake.
Methods A total of 5,563 residents of Wajima City who were not receiving oral treatment for anemia and who had received basic health screenings for fiscal years (FYs) 2006 and 2007, before and after the earthquake. We analyzed changes in their RBCs, Hb, and Ht levels by gender, age, body mass index (BMI), level of property damage, and evaluation standards.
Results RBCs, Hb, and Ht for FY2007 showed a trend of decreasing values compared to FY2006 in both male and female subjects. RBCs and Hb significantly decreased in females aged between 65 and 74 years who experienced total property damage, and Ht significantly increased for those younger than 65 years who experienced the same level of damage. In addition, significant differences by degree of property damage and FY2007/FY2006 ratio were seen only among subjects with a BMI ratio <1. Furthermore, we found a significant relationship between reduction of RBCs or Hb and increasing age in females; however, no significant relationship to property damage was found. No significant relationships were found for males.
Conclusions A significant association between property damage and changes in RBCs, Hb, and Ht was not found in this population of residents who experienced the Noto Peninsula Earthquake.

Keywords Noto Peninsula Earthquake · Depopulated area · Elderly · Basic health screening · Anemia

Introduction

Earthquakes instantaneously change areas residents have become accustomed to, bringing marked transformations to their living environments. The Noto Peninsula Earthquake, which occurred at 9:42 a.m. on Sunday 25 March 2007 with a magnitude of 6.9 and a seismic intensity 6+, resulted in 2,426 completely and half-destroyed residential buildings and 26,956 partially damaged buildings. One person died and 359 were injured by the earthquake. More than 2,500 were evacuated to temporary shelters. The earthquake occurred in an aging region designated as underpopulated by the Act on Special Measures for Promotion for Independence for Underpopulated Areas. Other massive earthquakes have since occurred, including the Niigata-Chuetsu Offshore Earthquake, the Iwate-Miyagi Inland Earthquake, and the Great East Kanto Earthquake. In these situations, the elderly often must take the initiative in dealing with post-disaster restoration and reconstruction. To successfully rebuild a community, prevention of deteriorating health conditions among residents becomes a crucial issue.

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There have been numerous reports on the impact of earthquake disasters on the circulatory system, such as the greater likelihood of heart disease after disasters [1], increased mortality from cardiovascular disease after the Great Hanshin-Awaji Earthquake of 1995 [2], and a high incidence of acute myocardial infarction in elderly females during the acute phase after an earthquake [3]. Some of these studies used objective indicators before and after the disaster, including a study by Tsuzuki et al. [4] with basic health screening results before and after the Great Hanshin-Awaji Earthquake, and a report on outpatients with high blood pressure [5]. Few of these reports, however, targeted an entire region [4, 6]. Few reports have also examined the impact of natural disasters on levels of hemoglobin (Hb), a diagnostic indicator of anemia, and hematocrit (Ht), a risk factor for acceleration of blood coagulation, in relation to gender, age, and level of property damage experienced. Results from basic health screenings by Tsuzuki et al. revealed no significant difference in RBCs, Hb, and Ht before, immediately after, and half a year after the earthquake in regions where total and half-damaged properties comprised $\geq$20 % of properties. For regions where total and half-damaged properties comprised $\leq$20 %, Ht significantly decreased 6 months after the earthquake compared to 2 months after the earthquake. Collectively, these results revealed no definite trend, suggesting the need for surveys that consider the target population and regionality.

In order to execute assistance programs that take into account damage and living circumstances, it is necessary to perform a multifaceted examination of the health of communities impacted by earthquakes. However, there are some difficulties (e.g., ethical aspects) in conducting investigations of residents immediately after a disaster. We therefore decided to examine residents' health conditions and determine the issues to address by using results of basic health screenings carried out by local governments in regions with aging populations. Prior to carrying out this study, upon analyzing data from the study subjects with a focus on blood pressure, we found that the body mass index (BMI) of disaster victims is reduced even 6 months after an earthquake and is lower for males the greater the level of damage they experience [7]. Although there was no consistent trend in blood pressure fluctuations for females whose homes were completely destroyed, their diastolic pressure increased significantly compared to those with other levels of damage. In the present study, we focused on red blood cells (RBCs), Hb, and Ht, which are important health indicators of anemia, and examined the impact of the earthquake based on the degree of property damage and age. We believe that our results will be invaluable as basic reference materials for determining specific health management policies and guidance for earthquake disaster victims.

Materials and methods

Subjects

Wajima is located on the northern tip of the Noto Peninsula in Japan. As of 1 April 2006, it was an area where the proportion of elderly residents increased at a rate of 35.8 % [8]. Temporary housing was established 2 months after the earthquake and maintained for 2 years. Subjects were residents of Wajima who underwent consecutive basic health screenings the year before the earthquake in fiscal year (FY) 2006 and FY2007. Basic health screenings targeted residents aged 40 years or older who did not receive an occupational health check. Screenings were performed individually or in a group setting, depending on personal convenience. A majority of the health screenings occurred from September to October, and the screening rate for FY2006 was 47.5 % [9].

The number of residents examined was 7,542 in FY2006 and 7,394 in FY2007; 5,693 were examined consecutively. This study examined the records of 5,563 residents after excluding 108 undergoing oral therapy to exclude the effects of anemia treatments and 22 with missing data.

Measurements

We obtained basic health screening measurements from FY2006 and FY2007 in Wajima, as well as records on the level of earthquake damage experienced by the screened subjects. The two disparate sets of information were linked to the correct individuals by an administrator in charge of personal information. Personal medical data were handled by the use of encoded data with only numbers to identify individuals.

Of the items in the basic health screening test, gender, age, RBCs, Hb, Ht, and BMI (an indicator of nutritional status) were used for this study.

The age given at the FY2006 screening test was used to categorize subjects.

Subjects were categorized into three groups: those younger than 65 years, those between 65 and 74 years, and those 75 years or older.

Classification of property damage was conducted in consultation with the University of Noto Peninsula's seismological department to confirm the validity of indices evaluating the degree of damage caused by the earthquake. This method of assessing property damage was considered adequate in the absence of more detailed information, such as the seismic intensity experienced at a given location. The level of property damage was also classified into three groups: total damage (including large-scale half damage), half damage (half of total damage), and partial damage (including light damage). Total damage to property is determined by the degree of collapse of a dwelling, the slanting of outer walls and columns, and the foundation damage rate, and refers to homes with a damage rate ≥50 % [10] that would be difficult to live in without major repairs. From the day of the earthquake, disaster victims must live in evacuation centers or temporary housing for long periods. Moreover, the disaster influences all aspects of their lives, including economic, housing, and job-related aspects, and has a long-term impact on mental health [11]. Half damage to property reflects a damage rate <50 %. However, based on the extent of damage, it may difficult to live at home and, just like those who experienced total damage, residents are greatly influenced by the earthquake until repairs are completed. On the other hand, partial damage to property relates to a damage rate <20 % [10]. While repairs are needed, the home is habitable and residents can continue living there. When considering the impact of an earthquake on health, it is necessary to consider the degree of property damage, as the home serves as the base for living.

RBCs, Hb, and Ht were measured based on quality control standards stipulated in the manual of test value standardization at the same test facility that participates in the Project on Assurance and Standardization of Clinical Laboratory Quality sponsored by the Prefectural Medical Association [12]. RBC, Hb, and Ht data were grouped using classification criteria. Evaluation standards of the Wajima health screening test were used for RBCs and Ht. Standard values were: RBCs: male 410–530 × 104/μl; female 380–480 × 104/μl, Hb: male 13.0–18.0 g/dl, female 12.0–16.0 g/dl. For Hb, the WHO diagnostic criteria were used for minimum values as the mean age was over 70 years, and standard values for Wajima were used for the maximum. Ht values were: male 39.0–52.0 %, female 35.0–48.0 %. Standard values for BMI were 18.5–25.0 kg/m^2 for both males and females.

The present study was carried out with approval from the Ethics Committee of the Kanazawa University School of Medicine.

Statistical analysis

McNemar's test was used to determine changes in RBC, Hb, and Ht standard values. RBCs, Hb, and Ht were calculated based on the ratio of levels in 2007 to levels in 2006 (hereafter, rate of change), and correlations were examined with age and rate of change in BMI. To assess changes in RBCs, Hb, and Ht, we used paired *t*-tests according to gender, age, rate of change in BMI, and the level of damage experienced. In addition, the ratios of FY2007 values to FY2006 values were analyzed by the level of damage experienced with either one-way analysis of variance or the Kruskal-Wallis test. Multiple comparisons were examined with the Tukey-Kramer HSD test. As for factors affecting RBCs, Hb, and Ht, the change in ratios of each were examined by setting the target variable to 1 or 0 if there was an increase or decrease after the earthquake, respectively, and using separate multiple logistic models for males and females with age, change in BMI ratios, and level of damage experienced as explanatory variables. For the level of damage experienced, two quantities—total damage to partial damage and half damage against partial damage—were treated as dummy variables. For statistical analysis, JMP 6.0 (SAS Institute, Japan) was used with significance set at $p < 0.05$.

Results

Subject characteristics

The mean age of subjects was 72.6 ± 9.8 years for males and 70.5 ± 11.3 years for females. Residential homes were completely destroyed for 5.5 % of males and 6.1 % of females, and half-destroyed for 7.6 % of males and 8.2 % of females. Temporary housing was used by 1.6 % of males and 2.1 % of females (Table 1).

Evaluation based on classification criteria

The proportion of males with Hb and Ht below the standard value increased significantly in FY2007 following the earthquake. The proportion of females with RBCs, Hb, and Ht below their respective standard values also significantly increased in FY2007 (Table 2).

Table 1 Subject characteristics

	Male (n = 1,911)		Female (n = 3,652)	
	n	%	n	%
Age				
Younger than 65	411	21.5	990	27.1
Between 65 and 74 years	696	36.4	1,371	37.5
75 years or older	804	42.1	1,291	35.4
Damage to property				
Total damage[a]	105	5.5	223	6.1
Half damage	145	7.6	299	8.2
Partial damage	1,661	86.9	3,130	85.7
Post-disaster housing				
Temporary housing	30	1.6	77	2.1
Own housing	1,848	96.7	3,516	96.3
Other	33	1.7	59	1.6

[a] "Total damage" includes "near total damage"

Table 2 Anemic characteristic comparisons before and after the earthquake using standard values

	RBCs (10^4/μl)			Hb (g/dl)			Ht (%)		
	FY2006	FY2007	*p*	FY2006	FY2007	*p*	FY2006	FY2007	*p*
Male (*n* = 1,911)									
Less than standard value (%)	490 (25.6)	536 (28.0)	**	373 (19.5)	444 (23.2)	***	403 (21.1)	480 (25.1)	***
Standard value (%)	1,359 (71.1)	1,322 (69.2)		1,526 (79.9)	1,458 (76.3)		1,491 (78.0)	1,416 (74.1)	
Greater than standard value (%)	62 (3.2)	53 (2.8)		12 (0.6)	9 (0.5)		17 (0.9)	15 (0.8)	
Female (*n* = 3,652)									
Less than standard value (%)	742 (20.3)	897 (24.6)	***	907 (24.8)	1,102 (30.2)	***	568 (15.6)	671 (18.4)	***
Standard value (%)	2,764 (75.7)	2,575 (70.5)		2,739 (75.0)	2,543 (69.6)		3,077 (84.3)	2,973 (81.4)	
Greater than standard value (%)	146 (4.0)	180 (4.9)		6 (0.2)	7 (0.2)		7 (0.2)	8 (0.2)	

McNemar test

RBCs red blood cells, *Hb* hemoglobin, *Ht* hematocrit

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3 Rate of change of RBCs, Hb, and Ht, and their correlation with age and BMI rate of change

	M	SD	FY2007/FY2006 BMI	FY2007/FY2006 RBC	FY2007/FY2006 Hb	FY2007/FY2006 Ht
Male (*n* = 1,911)						
Age as of FY2006	71.526	9.810	−0.081***	−0.027	−0.055*	−0.017
FY2007/FY2006 BMI	0.996	0.040		0.067***	0.040	0.023
FY2007/FY2006 RBC	0.991	0.063			0.844***	0.840***
FY2007/FY2006 Hb	0.987	0.064				0.850***
FY2007/FY2006 Ht	0.988	0.067				
Female (*n* = 3,652)						
Age as of FY2006	69.403	11.256	−0.034*	−0.064***	−0.053***	−0.027
FY2007/FY2006 BMI	0.998	0.044		0.034*	0.012*	0.007**
FY2007/FY2006 RBC	0.991	0.057			0.736***	0.813***
FY2007/FY2006 Hb	0.988	0.066				0.848***
FY2007/FY2006 Ht	0.990	0.062				

Pearson's correlation coefficient. Rate of change; FY2007/FY2006

RBCs red blood cells, *Hb* hemoglobin, *Ht* hematocrit

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Correlation between rate of change in RBCs, Hb, and Ht, and age and rate of change in BMI

While RBCs, Hb, and Ht were correlated among each other in both males and females, the correlation of these parameters with rate of change in BMI was low (Table 3).

Changes in RBCs before and after the earthquake

RBCs significantly decreased among all males, all males in each age group, all males in each age group with a BMI ratio <1, and males who experienced partial damage. Among males aged 75 years or older, RBCs significantly decreased in those who experienced even half damage. There was no significant difference in rates of change by degree of property damage.

RBCs significantly decreased among all females, all females in each age group, all females in each age group with a BMI ratio < 1, and females who experienced partial damage. There was a significant decrease in RBCs in females who experienced total damage among those aged between 65 and 74 years and 75 years and older. In comparisons based on degree of property damage, among those with a BMI ratio <1 and aged between 65 and 74 years, the rate of change in RBCs in those who experienced full property damage was significantly lower than in those who experienced partial damage (Table 4).

Changes in Hb levels before and after the earthquake

Hb significantly decreased among all males, all males in each age group, all males in each age group with a BMI ratio <1, and males who experienced partial damage. Among males aged 75 or older, Hb significantly decreased in those who experienced total and half damage. There was no significant difference in rate of change by degree of property damage.

Hb significantly decreased among all females, all females in each age group, and, with respect to females with a BMI ratio < 1, a significant decrease was observed with the exception of those younger than 65 years who experienced total damage and those older than 75 years who experienced half damage. In comparisons based on degree of property damage, among females with a BMI ratio < 1 and aged younger than 65 years, the rate of change in those who experienced full damage was significantly higher than in those who experienced half and partial damage. Among females aged 75 years or older, Hb was significantly lower in those who experienced partial damage than in those who experienced half damage (Table 5).

Changes in Ht values before and after the earthquake

Ht significantly decreased among all males, all males in each age group, all males in each age group with a BMI ratio <1, and males who experienced partial damage. In comparisons based on degree of property damage, males aged between 65 and 74 years with a BMI ratio <1 showed a significantly lower rate of change in those who experienced half damage than in those who experienced partial damage. Among males with a BMI ratio ≥1, the rate of change was significantly higher among those who experienced half damage than in those who experienced partial damage.

Ht values significantly decreased among all females, all females in each age group, all females in each age group with a BMI ratio <1, and females who experienced partial damage. In comparisons based on degree of property damage, among females with a BMI ratio <1 and younger than 65 years, the rate of change in those who experienced full property damage was significantly higher than in those who experienced partial damage. For females aged 75 years or older, the rate of change in those who experienced half damage was significantly higher than in those who experienced partial damage (Table 6).

Factors influencing fluctuations in RBCs, Hb, and Ht

There was no indication of a significant relationship between any of the variables and RBCs and Hb among males. Among females, however, RBCs and Hb declined with increasing age ($p = 0.019$, $p < 0.001$). A significant relationship was not observed between degree of property damage and hematologic markers with logistic regression analyses (Table 7).

Discussion

In this study, we examined data related to anemia from basic health screenings of local residents before and after the Noto Peninsula Earthquake. Although not all residents in the region underwent basic health screenings, more than 96 % of subjects in this study lived at home after the earthquake. While field surveys are sometimes necessary after a disaster, it may be possible to lessen the burden of carrying out surveys aimed at implementing health maintenance and guidance by using health screening data. This study may provide valuable basic information for the development of health support measures not only for individuals living in earthquake shelters and temporary housing, but also for those residing at home across the entire region.

Comparing mean RBCs, Hb, and Ht by age before and after the earthquake with results of the 2006 National Health and Nutrition Examination Survey [13], values were higher in males than in females, and their reduction with increasing age was consistent with the results of the national survey. In addition, mean RBCs, Hb, and Ht peaked for females in their 50s or 60s and gradually decreased after 70 years of age, reflecting similar changes in the national survey findings.

When the results were arranged by classification criteria, the number of individuals below the standard value for RBCs, Hb, and Ht in females and for Hb and Ht in males increased significantly after the earthquake. Mori [14] reported that more than 20 % of elderly individuals correspond to Hb levels below the standard value when the WHO diagnostic criteria for anemia are applied. More than 20 % of males and females corresponded to these levels in the present study as well, and this proportion increased significantly after the earthquake. Because these subjects comprised a non-treatment group, of which about half consisted of late stage elderly individuals, it underscores the necessity of monitoring merging anemic trends in the elderly after disasters. Primary anemia that accompanies aging has been reported to decrease as subjects grow older, although the prevalence of secondary anemia increases with age [15]. After a natural disaster, however, elderly individuals also face marked changes in their living environment (e.g., moving into temporary housing, and reconstructing damaged homes and the region). This may have increased stress and worsened pre-existing chronic diseases. The psychological influence of natural disasters

Table 4 Changes in red blood cells from basic health screenings before and after the earthquake sorted by gender, age, BMI, and level of damage experienced

Level of damage	Age			RBC									
				FY2006		FY2007			FY 2007/2006				
	M	SD	*n*	M	SD	M	SD	p^a	M	SD	p^b	Combination of two groups	p^c
Male (*n* = 1,911)													
Younger than 65 years													
BMI ratio ≥1[e]													
1. Total damage[d]	56.4	9.6	5	516.8	14.0	513.0	18.2	0.699	0.993	0.040		1:2	
2. Half damage	56.0	6.7	14	460.6	34.5	456.9	38.3	0.376	0.992	0.033	0.919	1:3	
3. Partial damage	57.0	5.8	198	470.3	41.5	468.4	41.2	0.276	0.997	0.055		2:3	
Average	56.9	6.0	217	470.8	41.3	468.7	41.2	0.205	0.997	0.054			
BMI ratio <1[e]													
1. Total damage[d]	57.1	5.9	20	463.8	40.6	458.9	44.1	0.449	0.991	0.063		1:2	
2. Half damage	57.7	5.9	9	483.6	40.9	467.4	42.2	0.196	0.969	0.072	0.628	1:3	
3. Partial damage	57.1	5.9	165	467.0	43.8	460.4	46.5	0.002**	0.987	0.057		2:3	
Average	57.1	5.8	194	467.4	43.3	460.6	45.9	<0.001**	0.986	0.058			
Average	57.0	5.9	411	469.2	42.2	464.9	43.6	<0.001**	0.992	0.056			
Between 65 and 74 years													
BMI ratio ≥ 1													
1. Total damage[d]	68.0	1.9	9	446.6	30.7	435.4	32.7	0.078	0.975	0.036		1:2	
2. Half damage	70.4	2.6	25	445.5	63.9	435.4	65.9	0.013*	0.977	0.048	0.108	1:3	
3. Partial damage	69.9	2.8	323	447.3	42.9	446.7	43.1	0.660	1.000	0.064		2:3	
Average	69.9	2.8	357	447.2	44.3	445.6	44.8	0.260	0.998	0.063			
BMI ratio <1[e]													
1. Total damage[d]	70.5	3.0	20	439.5	39.1	435.0	30.9	0.367	0.992	0.049		1:2	
2. Half damage	70.0	2.3	26	441.7	32.3	446.2	39.9	0.401	1.011	0.062	0.268	1:3	
3. Partial damage	70.2	2.8	293	449.4	51.1	443.8	50.7	0.002**	0.989	0.065		2:3	
Average	70.2	2.8	339	448.2	49.2	443.4	49.0	0.003**	0.991	0.064			
Average	70.0	2.8	696	447.7	46.7	444.5	46.9	0.003**	0.995	0.063			
75 years or older													
BMI ratio ≥1[e]													
1. Total damage[d]	79.7	3.7	23	423.8	44.5	414.3	46.5	0.224	0.980	0.080		1:2	
2. Half damage	80.9	4.9	35	411.2	48.3	402.9	49.4	0.120	0.982	0.075	0.637	1:3	
3. Partial damage	80.1	4.2	325	427.9	52.6	423.1	54.2	0.001**	0.990	0.062		2:3	
Average	80.1	4.2	383	426.1	51.9	420.7	53.6	<0.001**	0.989	0.065			
BMI ratio <1[e]													
1. Total damage[d]	79.6	3.6	28	426.6	47.8	413.0	47.3	0.068	0.972	0.091		1:2	
2. Half damage	79.9	4.3	36	410.9	52.0	401.4	47.3	0.019*	0.980	0.060	0.293	1:3	
3. Partial damage	80.5	4.5	357	419.3	43.9	414.8	49.0	0.002**	0.990	0.064		2:3	
Average	80.4	4.4	421	419.0	44.9	413.5	48.8	<0.001**	0.988	0.066			
Average	80.2	4.3	804	422.4	48.5	416.9	51.2	<0.001**	0.988	0.065			
Average	71.5	9.8	1,911	441.7	50.0	437.3	51.6	<0.001**	0.991	0.063			
Female (*n* = 3,652)													
Younger than 65 years													
BMI ratio ≥ 1[e]													
1. Total damaged	56.4	8.2	28	427.7	39.0	426.7	41.3	0.819	0.999	0.056		1:2	
2. Half damage	52.7	9.7	31	434.2	31.6	430.0	39.1	0.321	0.990	0.054	0.792	1:3	
3. Partial damage	54.5	8.8	481	432.1	34.9	430.3	37.6	0.091	0.997	0.053		2:3	
Average	54.5	8.8	540	432.0	34.9	430.1	37.8	0.0584	0.996	0.053			

Table 4 continued

Level of damage	Age			RBC									
				FY2006		FY2007			FY 2007/2006				
	M	SD	*n*	M	SD	M	SD	p^{a}	M	SD	p^{b}	Combination of two groups	p^{c}
BMI ratio <1[e]													
1. Total damaged	55.8	7.3	33	426.3	34.3	425.8	37.5	0.911	1.000	0.055		1:2	
2. Half damage	59.8	5.0	23	440.1	38.0	429.5	49.1	0.054	0.975	0.057	0.136	1:3	
3. Partial damage	55.0	9.0	394	433.5	33.3	431.4	33.5	0.065	0.996	0.052		2:3	
Average	55.3	8.8	450	433.3	33.7	430.9	34.7	0.025*	0.996	0.052			
Average	54.9	8.8	990	432.6	34.3	430.5	36.4	0.004**	0.996	0.053			
Between 65 and 74 years													
BMI ratio ≥1[e]													
1. Total damage[d]	71.1	2.8	34	406.1	39.4	398.1	44.3	0.022*	0.980	0.048		1:2	
2. Half damage	70.6	2.7	55	406.1	39.4	399.7	46.1	0.153	0.990	0.056	0.250	1:3	
3. Partial damage	69.8	2.9	623	413.3	33.5	410.5	36.7	0.001**	0.994	0.051		2:3	
Average	69.9	2.9	712	412.2	34.6	409.1	38.0	<0.001**	0.993	0.051			
BMI ratio <1[e]													
1. Total damage[d]	70.3	3.1	38	422.2	34.2	407.2	36.3	<0.001**	0.965	0.050		1:2	0.267
2. Half damage	70.1	3.0	68	413.7	35.6	406.3	37.2	0.016*	0.983	0.058	0.011*	1:3	0.013*
3. Partial damage	70.1	2.9	553	414.8	39.7	411.1	40.5	<0.001**	0.993	0.058		2:3	0.415
Average	70.1	2.9	659	415.1	39.0	410.4	39.9	<0.001**	0.990	0.058			
Average	70.0	2.9	1,371	413.6	36.79	409.7	38.91	<0.001**	0.992	0.054			
75 years or older													
BMI ratio ≥1[e]													
1. Total damage[d]	80.1	4.6	39	388.7	36.1	380.8	31.2	0.034*	0.982	0.056		1:2	
2. Half damage	79.6	4.6	59	388.3	40.7	380.4	45.3	0.017*	0.980	0.065	0.483	1:3	
3. Partial damage	79.8	4.1	536	395.1	43.7	390.0	44.5	<0.001**	0.989	0.057		2:3	
Average	79.8	4.2	634	394.0	43.0	388.5	43.9	<0.001**	0.987	0.058			
BMI ratio <1[e]													
1. Total damage[d]	80.3	3.8	51	401.6	42.7	390.9	40.6	0.001**	0.975	0.050		1:2	
2. Half damage	80.0	4.0	63	396.3	34.5	394.6	40.3	0.668	0.997	0.077	0.193	1:3	
3. Partial damage	80.0	4.0	543	397.5	43.1	391.1	45.1	<0.001**	0.985	0.067		2:3	
Average	80.0	4.0	657	397.7	42.3	391.4	44.2	<0.001**	0.986	0.067			
Average	79.9	4.1	1,291	395.9	42.68	390	44.1	<0.001**	0.987	0.063			
Average	69.4	11.3	3,652	412.5	41.0	408.4	43.2	<0.001**	0.991	0.057			

* $p < 0.05$, ** $p < 0.01$

M mean, *SD* standard deviation

[a] Corresponding *t*-test for health screenings in FY 2006 and 2007

[b] One-way analysis of variance by the ratio of FY 2007 to FY 2006

[c] Multiple comparison by the ratio of FY 2007 to FY 2006

[d] "Total damage" includes "near total damage"

[e] BMI FY2007/2006

on elderly individuals is reportedly greater than that experienced by younger individuals [16].

RBCs, Hb, and Ht tended to decrease in all age groups after the earthquake compared to before the earthquake. Logistic regression analysis revealed that the degree of property damage had no influence on these parameters. This may reflect the fact that the number of homes with total damage or half damage was less than 10 % that of homes with partial damage, i.e., there was a large difference in number of homes between groups.

Among individuals with a BMI ratio <1, RBCs, Hb, and Ht significantly differed by degree of property damage. In

Table 5 Changes in hemoglobin from basic health screenings before and after the earthquake sorted by gender, age, BMI, and level of damage experienced

Level of damage	Age			FY2006		FY2007			Hb				
									FY2007/2006				
	M	SD	*n*	M	SD	M	SD	p^a	M	SD	p^b	Combination of two groups	p^c
Male ($n = 1{,}911$)													
Younger than 65 years													
BMI ratio ≥1[e]													
1. Total damage[d]	56.4	9.6	5	15.60	0.92	15.44	0.80	0.607	0.991	0.040		1:2	
2. Half damage	56.0	6.7	14	14.65	1.01	14.56	1.09	0.528	0.994	0.036	0.993	1:3	
3. Partial damage	57.0	5.8	198	14.79	1.12	14.68	1.12	0.033*	0.994	0.055		2:3	
Average	56.9	6.0	217	14.80	1.11	14.69	1.11	0.023*	0.993	0.053			
BMI ratio <1[e]													
1. Total damage[d]	57.1	5.9	20	14.92	1.24	14.87	1.37	0.785	0.997	0.062		1:2	
2. Half damage	57.7	5.9	9	15.67	1.36	15.03	1.49	0.098	0.961	0.065	0.241	1:3	
3. Partial damage	57.1	5.9	165	14.90	1.19	14.71	1.26	0.002**	0.988	0.053		2:3	
Average	57.1	5.8	194	14.94	1.20	14.74	1.28	0.001**	0.988	0.055			
Average	57.0	5.9	411	14.87	1.16	14.7	1.2	<0.001**	0.991	0.054			
Between 65 and 74 years													
BMI ratio ≥1[e]													
1. Total damage[d]	68.0	1.9	9	14.88	1.15	14.28	1.32	0.014*	0.959	0.039		1:2	
2. Half damage	70.4	2.6	25	14.40	2.06	14.03	1.96	0.013*	0.976	0.048	0.069	1:3	
3. Partial damage	69.9	2.8	323	14.35	1.33	14.26	1.38	0.077	0.995	0.061		2:3	
Average	69.9	2.8	357	14.37	1.38	14.25	1.42	0.009**	0.993	0.060			
BMI ratio <1[e]													
1. Total damage[d]	70.5	3.0	20	14.06	1.15	13.92	0.93	0.449	0.993	0.056		1:2	
2. Half damage	70.0	2.3	26	14.17	1.52	14.11	1.45	0.732	0.999	0.078	0.634	1:3	
3. Partial damage	70.2	2.8	293	14.43	1.45	14.22	1.48	<0.001**	0.987	0.066		2:3	
Average	70.2	2.8	339	14.39	1.44	14.19	1.45	<0.001**	0.988	0.066			
Average	70.0	2.8	696	14.38	1.41	14.22	1.43	<0.001**	0.991	0.063			
75 years or older													
BMI ratio ≥1[e]													
1. Total damage[d]	79.7	3.7	23	13.72	1.26	13.23	1.41	0.025*	0.965	0.072		1:2	
2. Half damage	80.9	4.9	35	13.24	1.33	13.11	1.45	0.415	0.992	0.070	0.343	1:3	
3. Partial damage	80.1	4.2	325	13.70	1.69	13.43	1.73	<0.001**	0.982	0.067		2:3	
Average	80.1	4.2	383	13.66	1.64	13.39	1.69	<0.001**	0.982	0.067			
BMI ratio <1[e]													
1. Total damage[d]	79.6	3.6	28	13.60	1.53	12.96	1.45	0.014*		0.958	0.098	1:2	
2. Half damage	79.9	4.3	36	13.49	1.57	13.03	1.43	0.004**	0.969	0.073	0.069	1:3	
3. Partial damage	80.5	4.5	357	13.50	1.33	13.30	1.44	<0.001**	0.986	0.069		2:3	
Average	80.4	4.4	421	13.51	1.36	13.25	1.44	<0.001**	0.983	0.072			
Average	80.2	4.3	804	13.58	1.50	13.32	1.56	<0.001**	0.982	0.070			
Average	71.5	9.8	1,911	14.15	1.49	13.95	1.55	<0.001**	0.987	0.064			
Female ($n = 3{,}652$)													
Younger than 65 years													
BMI ratio ≥1[e]													
1. Total damage[d]	56.4	8.2	28	12.93	1.45	12.84	1.42	0.575	0.996	0.075		1:2	
2. Half damage	52.7	9.7	31	13.16	1.17	12.90	1.25	0.023*	0.980	0.045	0.568	1:3	
3. Partial damage	54.5	8.8	481	13.04	1.11	12.93	1.16	0.003**	0.994	0.068		2:3	
Average	54.5	8.8	540	13.04	1.13	12.92	1.18	<0.001**	0.993	0.068			

Table 5 continued

Level of damage	Age			FY2006		FY2007			Hb				
									FY2007/2006				
	M	SD	*n*	M	SD	M	SD	p^a	M	SD	p^b	Combination of two groups	p^c
BMI ratio <1[e]													
1. Total damage[d]	55.8	7.3	33	12.73	1.40	12.92	0.78	0.413	1.028	0.149		1:2	0.005**
2. Half damage	59.8	5.0	23	13.63	1.25	13.23	1.63	0.018*	0.969	0.059	0.004**	1:3	0.013*
3. Partial damage	55.0	9.0	394	13.13	1.14	13.00	1.08	<0.001**	0.992	0.060		2:3	0.265
Average	55.3	8.8	450	13.13	1.17	13.00	1.09	0.001**	0.993	0.071			
Average	54.9	8.8	990	13.08	1.15	12.96	1.14	<0.001**	0.993	0.069			
Between 65 and 74 years													
BMI ratio ≥1[e]													
1. Total damage[d]	71.1	2.8	34	12.83	1.33	12.51	1.36	0.003**	0.976	0.044		1:2	
2. Half damage	70.6	2.7	55	12.68	1.43	12.50	1.45	0.098	0.989	0.066	0.309	1:3	
3. Partial damage	69.8	2.9	623	12.78	0.99	12.66	1.12	<0.001**	0.990	0.053		2:3	
Average	69.9	2.9	712	12.78	1.04	12.64	1.16	<0.001**	0.990	0.054			
BMI ratio <1[e]													
1. Total damage[d]	70.3	3.1	38	12.99	1.27	12.57	1.28	<0.001**	0.968	0.047		1:2	
2. Half damage	70.1	3.0	68	13.00	0.94	12.70	1.09	0.003**	0.978	0.059	0.034*	1:3	
3. Partial damage	70.1	2.9	553	12.79	1.11	12.67	1.17	<0.001**	0.992	0.068		2:3	
Average	70.1	2.9	659	13.13	1.17	13.00	1.09	<0.001**	0.989	0.066			
Average	70.0	2.9	1,371	12.80	1.07	12.65	1.16	<0.001**	0.989	0.060			
75 years or older													
BMI ratio ≥1[e]													
1. Total damage[d]	80.1	4.6	39	12.22	0.98	11.87	1.09	0.001**	0.972	0.049		1:2	
2. Half damage	79.6	4.6	59	12.21	1.14	11.83	1.38	0.001**	0.969	0.071	0.388	1:3	
3. Partial damage	79.8	4.1	536	12.26	1.28	12.00	1.33	<0.001**	0.980	0.063		2:3	
Average	79.8	4.2	634	12.26	1.25	11.97	1.32	<0.001**	0.978	0.063			
BMI ratio <1[e]													
1. Total damage[d]	80.3	3.8	51	12.52	1.43	12.21	1.15	0.009**	0.980	0.082		1:2	0.128
2. Half damage	80.0	4.0	63	12.34	1.25	12.37	1.22	0.823	1.008	0.108	0.041*	1:3	0.9692
3. Partial damage	80.0	4.0	543	12.33	1.27	12.09	1.31	<0.001**	0.983	0.070		2:3	0.0352*
Average	80.0	4.0	657	12.34	1.28	12.13	1.29	<0.001**	0.985	0.076			
Average	79.9	4.1	1,291	12.30	1.27	12.05	1.31	<0.001**	0.982	0.070			
Average	69.4	11.3	3,652	12.70	1.21	12.52	1.26	<0.001**	0.988	0.066			

* $p < 0.05$, ** $p < 0.01$

M mean, *SD* standard deviation

[a] Corresponding *t*-test for health screenings in FY 2006 and 2007

[b] One-way analysis of variance by the ratio of FY 2007 to FY 2006

[c] Multiple comparison by the ratio of FY 2007 to FY 2006

[d] "Total damage" includes "near total damage"

[e] BMI FY2007/2006

males, Ht significantly differed only in those aged between 65 and 74 years. In women, RBCs significantly differed in those aged between 65 and 74 years, and Hb and Ht significantly differed in those 64 years and younger and those aged 75 years or older. While the trend was not constant, significant differences by degree of property damage and FY2007/FY2006 ratio were seen only with a BMI ratio <1. This suggests the possibility that changes in nutritional status may be related to RBCs, Hb, and Ht.

Ht was significantly lower in those who experienced less property damage, i.e., among men aged between 65 and 74 years and women younger than 65 or 75 years or older.

Table 6 Changes in hematocrit from basic health screenings before and after the earthquake sorted by gender, age, BMI, and level of damage experienced

Level of damage	Age			Ht									
				FY2006		FY2007			FY2007/2006			Combination of two groups	*p*[c]
	M	SD	*n*	M	SD	M	SD	*p*[a]	M	SD	*p*[b]		
Male (*n* = 1,911)													
Younger than 65 years													
BMI ratio ≥1[e]													
1. Total damage[d]	56.4	9.6	5	47.5	2.7	47.1	1.9	0.762	0.994	0.047		1:2	
2. Half damage	56.0	6.7	14	43.9	2.5	43.5	2.7	0.382	0.992	0.033	0.978	1:3	
3. Partial damage	57.0	5.8	198	44.5	3.4	43.9	3.2	0.003**	0.990	0.055		2:3	
Average	56.9	6.0	217	44.5	3.3	44.0	3.2	0.002**	0.991	0.054			
BMI ratio <1[e]													
1. Total damage[d]	57.1	5.9	20	44.2	3.6	43.9	3.8	0.607	0.994	0.068		1:2	
2. Half damage	57.7	5.9	9	45.6	4.4	44.3	4.2	0.225	0.973	0.070	0.643	1:3	
3. Partial damage	57.1	5.9	165	44.6	3.5	43.9	3.6	<0.001**	0.985	0.054		2:3	
Average	57.1	5.8	194	44.6	3.5	43.9	3.6	<0.001**	0.985	0.057			
Average	57.0	5.9	411	44.5	3.4	43.9	3.4	<0.001**	0.988	0.055			
Between 65 and 74 years													
BMI ratio ≥1[e]													
1. Total damage[d]	68.0	1.9	9	44.1	2.7	42.6	3.3	0.015*	0.965	0.034		1:2	0.859
2. Half damage	70.4	2.6	25	42.6	5.4	40.4	7.6	0.087	0.950	0.139	0.004**	1:3	0.387
3. Partial damage	69.9	2.8	323	42.9	3.8	42.7	3.8	0.099	0.996	0.063		2:3	0.005**
Average	69.9	2.8	357	42.9	3.9	42.5	4.2	0.011*	0.992	0.071			
BMI ratio <1[e]													
1. Total damage[d]	70.5	3.0	20	41.2	3.5	41.1	2.7	0.936	1.002	0.053		1:2	0.581
2. Half damage	70.0	2.3	26	41.7	4.0	42.4	3.7	0.190	1.021	0.074	0.027*	1:3	0.576
3. Partial damage	70.2	2.8	293	43.2	4.4	42.5	4.3	<0.001**	0.987	0.066		2:3	0.028*
Average	70.2	2.8	339	42.9	4.3	42.4	4.2	0.001**	0.990	0.066			
Average	70.0	2.8	696	42.9	4.1	42.5	4.2	<0.001**	0.991	0.069			
75 years or older													
BMI ratio ≥1[e]													
1. Total damaged	79.7	3.7	23	40.3	3.5	39.6	4.0	0.171	0.982	0.059		1:2	
2. Half damage	80.9	4.9	35	39.5	3.9	38.9	4.1	0.262	0.988	0.075	0.936	1:3	
3. Partial damage	80.1	4.2	325	41.2	4.9	40.5	5.0	<0.001**	0.984	0.066		2:3	
Average	80.1	4.2	383	41.0	4.7	40.3	4.9	<0.001**	0.984	0.066			
BMI ratio <1[e]													
1. Total damage[d]	79.6	3.6	28	40.9	4.6	39.4	4.2	0.036*	0.966	0.100		1:2	
2. Half damage	79.9	4.3	36	39.4	4.5	39.1	4.2	0.677	1.000	0.131	0.182	1:3	
3. Partial damage	80.5	4.5	357	40.3	3.9	39.8	4.2	<0.001**	0.988	0.062		2:3	
Average	80.4	4.4	421	40.3	4.0	39.7	4.2	<0.001**	0.988	0.074			
Average	80.2	4.3	804	40.6	4.4	40.0	4.5	<0.001**	0.986	0.070			
Average	71.5	9.8	1,911	42.3	4.4	41.7	4.5	<0.001**	0.988	0.067			
Female (*n* = 3,652)													
Younger than 65 years													
BMI ratio ≥1[e]													
1. Total damage[d]	56.4	8.2	28	39.0	4.0	38.9	3.9	0.937	1.001	0.065		1:2	
2. Half damage	52.7	9.7	31	39.8	3.3	39.1	3.4	0.050	0.983	0.050	0.508	1:3	
3. Partial damage	54.5	8.8	481	39.8	3.1	39.4	3.2	<0.001**	0.992	0.061		2:3	
Average	54.5	8.8	540	39.8	3.1	39.4	3.3	<0.001**	0.992	0.061			

Table 6 continued

Level of damage	Age			Ht									
				FY2006		FY2007			FY2007/2006			Combination of two groups	p^c
	M	SD	*n*	M	SD	M	SD	p^a	M	SD	p^b		
BMI ratio <1[e]													
1. Total damage[d]	55.8	7.3	33	38.9	3.5	39.5	2.4	0.317	1.022	0.104		1:2	0.041*
2. Half damage	59.8	5.0	23	40.6	3.7	40.0	4.6	0.187	0.983	0.056	0.016*	1:3	0.019*
3. Partial damage	55.0	9.0	394	39.9	3.1	39.5	2.8	0.001**	0.993	0.053		2:3	0.711
Average	55.3	8.8	450	39.9	3.2	39.6	2.9	0.005**	0.995	0.059			
Average	54.9	8.8	990	39.8	3.2	39.5	3.1	<0.001**	0.993	0.060			
Between 65 and 74 years													
BMI ratio ≥1[e]													
1. Total damage[d]	71.1	2.8	34	37.9	3.5	37.6	3.8	0.303	0.992	0.046		1:2	
2. Half damage	70.6	2.7	55	37.9	4.1	37.4	4.1	0.076	0.989	0.052	0.942	1:3	
3. Partial damage	69.8	2.9	623	38.7	3.0	38.3	3.3	<0.001**	0.991	0.058		2:3	
Average	69.9	2.9	712	38.6	3.1	38.2	3.4	<0.001**	0.991	0.057			
BMI ratio <1[e]													
1. Total damage[d]	70.3	3.1	38	38.9	3.7	38.0	3.7	0.009**	0.978	0.050		1:2	
2. Half damage	70.1	3.0	68	38.6	3.1	38.2	3.2	0.108	0.990	0.060	0.384	1:3	
3. Partial damage	70.1	2.9	553	38.7	3.4	38.3	3.4	<0.001**	0.993	0.064		2:3	
Average	70.1	2.9	659	38.7	3.4	38.3	3.4	<0.001**	0.991	0.063			
Average	70.0	2.9	1,371	38.7	3.2	38.3	3.4	<0.001**	0.991	0.060			
75 years or older													
BMI ratio ≥1[e]													
1. Total damage[d]	80.1	4.6	39	36.9	3.2	36.1	2.9	0.013*	0.981	0.050		1:2	
2. Half damage	79.6	4.6	59	36.2	3.3	35.6	3.9	0.043	0.983	0.066	0.961	1:3	
3. Partial damage	79.8	4.1	536	37.3	3.8	36.7	3.9	<0.001**	0.983	0.060		2:3	
Average	79.8	4.2	634	37.2	3.8	36.5	3.8	<0.001**	0.983	0.060			
BMI ratio <1[e]													
1. Total damage[d]	80.3	3.8	51	37.5	3.7	36.9	3.0	0.067	0.988	0.064		1:2	0.263
2. Half damage	80.0	4.0	63	36.9	3.6	37.1	3.7	0.634	1.010	0.100	0.051	1:3	0.976
3. Partial damage	80.0	4.0	543	37.4	3.8	36.8	3.8	<0.001**	0.986	0.069		2:3	0.039*
Average	80.0	4.0	657	37.4	3.7	36.8	3.8	<0.001**	0.989	0.073			
Average	79.9	4.1	1,291	37.3	3.7	36.7	3.8	<0.001**	0.986	0.067			
Average	69.4	11.3	3,652	38.5	3.5	38.0	3.6	<0.001**	0.990	0.062			

* $p < 0.05$, ** $p < 0.01$

M mean, *SD* standard deviation

[a] Corresponding t-test for health screenings in FY 2006 and 2007

[b] One-way analysis of variance by the ratio of FY 2007 to FY 2006

[c] Multiple comparison by the ratio of FY 2007 to FY 2006

[d] "Total damage" includes "near total damage"

[e] BMI FY2007/2006

This was particularly so when BMI was lower compared to before the earthquake. However, in the aftermath of the Niigata-Chuetsu Earthquake, males (mean age 40.2 years) who worked in disaster response showed significant increases in RBC and Ht even after 1 year from the earthquake, underscoring the need to prevent cardiovascular events [6]. In the group of individuals who experienced less damage after the Hanshin-Awaji Great Earthquake, Ht was significantly decreased a year after the earthquake compared to immediately after the earthquake [4]. Since the mean age of participants in that study was not disclosed, a simple comparison is not possible. However, the finding that the group that experienced less damage tended to have decreased Ht is similar to our results. In

Table 7 Factors influencing subject anemia characteristics

Factor	Coefficient	p	Odds ratio	95 % confidence interval
RBCs				
Male (n = 1,911)				
Age	−0.001	0.832	0.999	0.990–1.008
FY2007/FY2006 BMI	1.196	0.309	3.306	0.330–33.123
Level of damage experienced				
Total damage[a]/partial damage	−0.054	0.599	0.947	0.773–1.157
Half damage/partial damage	−0.111	0.212	0.895	0.750–1.064
Female (n = 3,652)				
Age	−0.012	<0.001**	0.988	0.982–0.994
FY2007/FY2006 BMI	1.395	0.070	4.036	0.892–18.269
Level of damage experienced				
Total damage[a]/Partial damage	−0.135	0.061	0.873	0.757–1.005
Half damage/Partial damage	0.032	0.607	1.032	0.915–1.164
Hb				
Male (n = 1,911)				
Age	−0.004	0.457	0.996	0.987–1.006
FY2007/FY2006 BMI	1.044	0.377	2.841	0.280–28.790
Level of damage experienced				
Total damage[a]/partial damage	−0.181	0.087	0.834	0.674–1.023
Half damage/partial damage	−0.137	0.127	0.872	0.729–1.038
Female (n = 3,652)				
Age	−0.007	0.019*	0.993	0.987–0.999
FY2007/FY2006 BMI	0.432	0.574	1.540	0.342–6.942
Level of damage experienced				
Total damage[a]/partial damage	−0.139	0.055	0.870	0.753–1.001
Half damage/partial damage	0.015	0.810	1.015	0.900–1.145
Ht				
Male (n = 1,911)				
Age	−0.001	0.888	0.999	0.990–1.009
FY2007/FY2006 BMI	1.282	0.278	3.605	0.355–36.660
Level of damage experienced				
Total damage[a]/partial damage	−0.002	0.987	0.998	0.814–1.219
Half damage/partial damage	−0.031	0.729	0.970	0.814–1.152
Female (n = 3,652)				
Age	−0.003	0.222	0.996	0.991–1.002
FY2007/FY2006 BMI	0.120	0.875	1.128	0.252–5.048
Level of damage experienced				
Total damage[a]/partial damage	−0.030	0.675	0.971	0.844–1.114
Half damage/partial damage	0.043	0.484	1.044	0.926–1.177

RBCs red blood cells, *Hb* hemoglobin, *Ht* hematocrit

*p < 0.05, **p < 0.01

[a] "Total damage" includes "near total damage"

order to determine whether Ht decreases after earthquakes in the chronic phase, i.e., more than 6 months after the earthquake, further assessments over time are needed. Acute stressors such as earthquakes were reported to worsen coronary atherosclerosis via actions in the sympathetic nervous system that promote arrhythmia and increase the stimulation of blood platelets, which in turn increases levels of Hb and Ht and elevates blood viscosity [17–20]. Stress levels increased in females younger than 65 years after a disaster, likely because of their increased activity levels, suggesting the necessity of support activities to prevent heart disease. Sensitivity to stress following a disaster is higher in females than males [21, 22], and being both elderly and female affects deterioration in quality of life [23]. The same situation likely occurred with the earthquake victims of the present study. Only female subjects showed a significant change in the ratios of RBCs and Hb. There was a decreasing trend with increased age and also with completely destroyed homes compared to partially damaged homes. Given that RBCs, Hb, and Ht naturally decline with age [24], the physiological effects described above are expected.

Hb significantly decreased among males who worked in disaster response 1 year after the Niigata-Chuetsu Earthquake [6]. In the present study as well, a significant decrease in Hb was seen in both males and females 6 months after the earthquake, suggesting that decreases in Hb after an earthquake continues for a long period. Various reasons may underlie this finding, such as stress resulting from changes in living environment, as well as weight loss due to decreased appetite. Particularly among females, a significant decrease in Hb was seen among those who experienced less property damage in the group in which BMI decreased compared to before the earthquake. Such an observation has not been previously reported. Given that BMI and Hb are both indicators of nutritional status, and the possibility of continuing to live at home when there is less property damage, being in an environment that enables one to observe the homes and region affected by the earthquake may serve as a stressing factor, possibly leading to decreased appetite and weight loss. Since differences in earthquake intensity, casualty figures, damage situation of houses, and age distribution of participants in previous studies make simple comparisons difficult, we believe that further accumulation of data on comparisons with results of other types of analyses is important.

Changes in the activity level of elderly individuals after a disaster can have a systemic effect. For elderly individuals to live an independent and active life, they should be provided with nutrition and health guidance. Although eating habits may be altered while living in temporary housing, access to detailed dietary information was difficult to obtain immediately following the earthquake. Collection of relevant indicators in this domain will be a future challenge.

Significant changes were observed among females when sorting data by age and degree of damage experienced. In particular, females younger than 65 years had significantly higher Ht levels when their homes were completely destroyed. Elevated Ht levels were reported for a group of subjects whose homes were completely destroyed in the Great Hanshin-Awaji Earthquake and remained elevated about 4–6 months after the disaster compared to immediately after the event [25].

Limitations

Our study has several limitations. The health screening data were not obtained immediately after the earthquake; therefore, we cannot comment on circulatory symptoms in that acute phase. Future research should aim to improve the generalizability of findings to other populations and disaster scenarios. Moreover, given that various stress factors, such as house repair plans and family composition, differ based on the amount of time after an earthquake [26, 27], it will be necessary to carry out continuous surveys.

While previous studies assessed the influence of earthquakes on health according to earthquake magnitude reported by the Meteorological Agency [3–6], the current study assessed various parameters by the degree of damage to homes, which form the foundation of living. Reasons for the absence of a control district were that the majority of the regions in the prefecture suffered damage, and information from other municipalities was unavailable. Basic personal information was not recorded during physical examinations, and therefore use of physical examination data was limited. Furthermore, comparisons between damaged and non-damaged property within the affected area were difficult and will be a future challenge. The health impact of an earthquake depends on its severity, demographics of the region, and the length of the recovery period. Although a significant relationship was not seen between property damage and anemia in the Noto Peninsula Earthquake, this study may serve as basic data for future studies of the impact of the 2011 Tohoku Earthquake.

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Conflict of interest The authors declare that they have no conflicts of interest.

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