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Physical activity and sedentary behavior among children and adolescents living in an area affected by the 2011 Great East Japan earthquake and tsunami for 3 years

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ABSTRACT

The purpose of this study is to examine the change in physical activity levels among children and adolescents living in the area affected by the 2011 earthquake and tsunami for 3 years immediately following the disaster. Children and adolescents graded four to nine and attending school in the Pacific coastal area of northern Japan were included in a total of four serial prevalence investigations: the first at 6 months after the earthquake/tsunami (I, $n = 434$) and additional surveys at 1 year (II, $n = 437$), 2 years (III, $n = 401$), and 3 years (IV, $n = 365$) after the earthquake. Students were also required to undergo assessment of their accelerometer-determined daily steps and sedentary time using a self-administrated questionnaire. Accelerometer-determined median daily steps of children and adolescents were significantly different ($p < 0.05$) on both weekdays and weekends over 3 years. The median daily steps of children of both genders on weekdays and those of girls on weekends at period IV were significantly lower than those at period I. In addition, the median daily steps of adolescents on weekdays among girls and weekends among boys at period IV were significantly lower than those at period I. It appears that children and adolescents who survive the earthquake and tsunami experience a decrease in physical activity levels. Future research should elucidate longitudinal demographic and sociocultural factors that contribute to changes in physical activity levels among children and adolescents living in the areas affected by these disasters.

Introduction

The 2011 Great East Japan Earthquake caused serious damage. Furthermore, the prefectures of Miyagi, Fukushima, and Iwate along the Pacific coast suffered devastating damage as a result of the tsunami caused by the earthquake. In association with the disaster, the daily life of many residents of these areas has altered.

A few previous studies have reported the health status of survivors after a disaster. For example, Wu et al. (2006) showed that the deteriorating quality of life (QOL) scores of the Chi-Chi earthquake survivors aged 16 years or older were decreased 3 years after the event. Another study (Ardalan et al., 2010) showed that QOL scores of elderly survivors 5 years post-earthquake disaster were also decreased.

Physical activity is an important factor affecting health indicators. Worldwide, public health guidelines recommend a physically active lifestyle for children and adolescents for overall health benefits (World Health Organization, 2010). QOL is one of the health indicators, and a study (Chen et al., 2005) has indicated that a consistently positive association exists between physical activity level and health-related QOL among children. Furthermore, sedentary behavior, such as sitting, is associated with health consequences and outcomes independent from the health benefits of physical activity (Tremblay et al., 2011; Owen et al., 2010).

Although physical activity is recommended for health, little is known about physical activity levels among victims of the 2011 earthquake and tsunami. In this study, we described changes in physical activity among children and adolescents living in the area affected by the 2011 earthquake and tsunami during the 3 years after the disaster.

Methods

Participants were elementary school students in 4th, 5th, and 6th grades and junior high school students in 7th, 8th, and 9th grades. Four-time surveys of this serial prevalence study were conducted at about 6 months (I, $n = 434$), 1 year (II, $n = 437$), 2 years (III, $n = 401$), and 3 years (IV, $n = 365$) after the earthquake in Onagawa, in the Miyagi prefecture, in the Pacific coastal area of northern Japan. Ethics approval for the present study was obtained from the Tohoku Gakuin University Ethics Committee, the Human Informatics postgraduate course, and the Catholic Education Commission. All participating students and their parents/legal guardians provided written informed consent.

All students were asked to report their gender, age, grade, height, and weight. BMI was calculated using their height and weight, and

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students were categorized as overweight, obese, or within the normal range according to international guidelines (Cole et al., 2000). In addition, total minutes per day spent in sedentary behavior were assessed by a self-reported questionnaire. The students were asked to reply to the question, "During the last week, how much time did you spend sitting on a weekday and weekend? Sitting includes watching TV, playing game, having a chat, reading, and listening to music at both school and home." This question was phrased according to the international physical activity questionnaire in a previous study. In addition, physical activity questions from the WHO health behavior in

Table 1
Characteristics, physical activity, and sedentary behavior among elementary school students.

	I	II	III	IV		
Girl, *n* (%)	108 (54)	108 (54)	82 (55)	57 (52)	n.s.	
Grade, *n* (%)						
4th	65 (33)	65 (33)	45 (31)	38 (33)	n.s.	
5th	66 (33)	66 (33)	55 (37)	33 (29)		
6th	69 (35)	69 (35)	47 (32)	43 (38)		
Body mass index, *n* (%)						
Normal	106 (83)	127 (84)	87 (81)	78 (81)	n.s.	
Overweight and obesity	21 (17)	25 (16)	21 (19)	18 (19)		
Physical activity of HBSC, *n* (%)						
Boys						
Active	62 (79)	59 (74)	50 (76)	37 (70)	n.s.	
Inactive	16 (21)	21 (26)	16 (24)	16 (30)		
Girls						
Active	49 (59)	42 (41)	34 (41)	28 (49)	n.s.	
Inactive	34 (41)	61 (59)	48 (59)	29 (51)		
Time spend on sitting, min/day						
Boys						
Weekday						
25 percent tile	321	189	223	206	n.s.	
50 percent tile	485	510	399	323		
75 percent tile	611	707	617	580		
Mean ± SD	485 ± 227	483 ± 277	431 ± 254	418 ± 265		
Weekend						
25 percent tile	305	238	248	347	n.s.	
50 percent tile	477	510	500	480		
75 percent tile	643	719	694	632		
Mean ± SD	480 ± 231	484 ± 271	484 ± 262	515 ± 221		
Girls						
Weekday						
25 percent tile	366	336	227	179	**	I > IV
50 percent tile	550	566	407	360		
75 percent tile	728	675	633	615		
Mean ± SD	533 ± 248	517 ± 242	435 ± 255	416 ± 278		
Weekend						
25 percent tile	304	289	285	324	n.s.	
50 percent tile	527	542	573	488		
75 percent tile	698	726	726	645		
Mean ± SD	532 ± 252	538 ± 247	539 ± 258	504 ± 242		
Steps per day						
Boys						
Weekday						
25 percent tile	11,209	9200	9627	8870	**	I > II, IV
50 percent tile	12,920	11,171	11,773	10,854		
75 percent tile	15,297	14,773	16,971	14,775		
Mean ± SD	13,582 ± 3733	12,138 ± 4447	1305 ± 4701	11,765 ± 4302		
Weekend						
25 percent tile	5925	4205	3751	5066	*	n.s.
50 percent tile	9698	6467	6510	7691		
75 percent tile	12,912	10,628	12,890	11,270		
Mean ± SD	10,128 ± 5278	8240 ± 5288	9292 ± 7965	8501 ± 5060		
Girls						
Weekday						
25 percent tile	7562	6780	7227	5947	***	I, III > II, IV
50 percent tile	8529	7836	8955	7475		
75 percent tile	9846	8925	11,066	8567		
Mean ± SD	8765 ± 1976	7913 ± 1767	9302 ± 2985	7609 ± 2382		
Weekend						
25 percent tile	4950	3049	3692	2769	***	I > II, III, IV
50 percent tile	7714	4748	5679	4903		
75 percent tile	10,555	7240	8215	6751		
Mean ± SD	8082 ± 4123	5349 ± 3053	6084 ± 3360	5372 ± 3752		

n.s.: not significant.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

schoolchildren (HBSC) survey, which has acceptable reliability and validity among children and adolescents, were also included in our questionnaire (Booth et al., 2001).

Accelerometer-determined steps per day were evaluated using a triaxial accelerometer device (Activity Style Pro HJA-350IT; Omron Healthcare, Kyoto, Japan) consisting of Micro Electro Mechanical Systems-based accelerometers (LIS3LV02DQ; ST-Microelectronics, Geneva, Switzerland) (Hikihara et al., 2014; Ohkawara et al., 2011). The accelerometers were initialized to concurrently record steps in 10-s intervals. Students were asked to wear the device for 7 or more consecutive

Table 2
Characteristics, physical activity, and sedentary behavior among junior high school students.

	I	II	III	IV		
Girl, *n* (%)	104 (48)	104 (48)	88 (49)	84 (57)	n.s.	
Grade, *n* (%)						
7th	70 (33)	70 (33)	65 (37)	42 (28)	n.s.	
8th	79 (37)	79 (37)	44 (25)	58 (38)		
9th	66 (31)	66 (31)	66 (38)	51 (34)		
Body mass index, *n* (%)						
Normal	157 (86)	129 (87)	129 (84)	115 (88)	n.s.	
Overweight and obesity	26 (14)	20 (13)	24 (16)	15 (12)		
Physical activity of HBSC, n (%)						
Boys						
Active	80 (78)	64 (82)	66 (73)	49 (77)	n.s.	
Inactive	23 (22)	14 (18)	24 (27)	15 (23)		
Girls						
Active	55 (57)	39 (46)	49 (56)	42 (50)	n.s.	
Inactive	41 (43)	46 (54)	39 (44)	42 (50)		
Time spend on sitting, min/day						
Boys						
Weekday						
25 percent tile	258	182	160	194	**	I > II, III, IV
50 percent tile	607	324	297	300		
75 percent tile	787	615	602	639		
Mean ± SD	547 ± 285	413 ± 272	390 ± 265	405 ± 265		
Weekend						
25 percent tile	345	390	266	333	n.s.	
50 percent tile	542	573	536	552		
75 percent tile	733	750	704	800		
Mean ± SD	546 ± 253	561 ± 251	497 ± 255	561 ± 270		
Girls						
Weekday						
25 percent tile	338	265	240	240	**	I > IV
50 percent tile	665	510	575	398		
75 percent tile	838	724	823	625		
Mean ± SD	596 ± 281	496 ± 270	533 ± 304	449 ± 260		
Weekend						
25 percent tile	460	426	313	345	n.s.	
50 percent tile	665	605	611	560		
75 percent tile	845	778	837	743		
Mean ± SD	633 ± 238	610 ± 240	575 ± 278	553 ± 243		
Steps per day						
Boys						
Weekday						
25 percent tile	6338	5494	6449	6014	n.s.	
50 percent tile	9586	9214	8067	9339		
75 percent tile	11,444	11,278	11,077	12,532		
Mean ± SD	9310 ± 3452	8947 ± 3765	8479 ± 3248	9507 ± 4430		
Weekend						
25 percent tile	3876	3287	3175	1718	***	I > IV
50 percent tile	6850	5085	5757	3337		
75 percent tile	13,418	7457	8416	7066		
Mean ± SD	8816 ± 6288	5843 ± 3741	6521 ± 4218	4947 ± 4646		
Girls						
Weekday						
25 percent tile	6521	5668	5962	5044	***	I > IV
50 percent tile	8275	7369	7315	6960		
75 percent tile	10,651	9589	8805	8731		
Mean ± SD	8815 ± 3370	7560 ± 2658	7343 ± 2396	6673 ± 2712		
Weekend						
25 percent tile	3251	3161	2949	1784	n.s.	
50 percent tile	4917	4805	4352	3253		
75 percent tile	7248	7804	6960	7185		
Mean ± SD	5784 ± 3609	5458 ± 3242	5414 ± 3801	4817 ± 4133		

n.s.: not significant.
** $P < 0.01$.
*** $P < 0.001$.

days including at least 2 weekend days, removing them only for water activities and before going to bed at night (Rowlands, 2007). The students were shown how to set the accelerometer to their waists during the training session. At least 3 days with more than 10 h of daily data collection, including 2 weekdays and 1 weekend day, were required for inclusion in the analysis. Data recorded on the first and last days were removed towing to some reactivity risks and incompleteness on these days.

All analyses were conducted using SPSS version 22.0 for Windows (Predictive Analytics Software, SPSS Inc., Chicago, IL, USA). Chi-square test was used to assess differences in gender, grade, and BMI categories (Cole et al., 2000). The total min per day spent sitting and the number of steps per day were analyzed using the non-parametric Kruskal–Wallis test. Post hoc comparisons for dichotomous variables were based on Mann–Whitney *U* tests with a Bonferroni corrected significance level. A p value < .05 was considered statistically significant.

Results

Table 1 shows the characteristics and physical activity levels among elementary school students. There were significant differences ($p < 0.05$) among children in the median time spent sitting on weekdays (Girls: $\chi^2 = 12.3$, $df = 3.0$) alone and accelerometer-determined median daily steps on both weekdays (Boys: $\chi^2 = 12.4$, $df = 3.0$; Girls: $\chi^2 = 27.5$, $df = 3.0$) and weekends (Boys: $\chi^2 = 8.0$, $df = 3.0$; Girls: $\chi^2 = 30.0$, $df = 3.0$). The median daily steps declined significantly for both genders on weekdays and for girls on weekends at period IV as compared with median daily steps at period I ($p < 0.05$), whereas the time spent sitting decreased on weekdays. Significant difference was seen in terms of the daily steps of the boys on weekends, whereas there were no differences among periods in the post hoc test.

Table 2 shows the characteristics and physical activity levels among junior high school students. There were significant differences ($p < 0.05$) among adolescents in the time spent sitting on weekdays (Boys: $\chi^2 = 16.8$, $df = 3.0$; Girls: $\chi^2 = 11.8$, $df = 3.0$) and in accelerometer-determined median daily steps on both weekdays (Girls: $\chi^2 = 17.9$, $df = 3.0$) and weekends (Boys: $\chi^2 = 15.6$, $df = 3.0$). The median daily steps declined significantly among girls on weekdays and among boys on weekends at period IV as compared with the median daily steps at period I ($p < 0.05$), whereas for girls, the time spent sitting on weekdays decreased.

Discussion

The present study showed that accelerometer-determined steps per day among children living in an area affected by earthquake and tsunami on both weekday and weekend decreased significantly, whereas the sedentary time among girls on weekdays only decreased over the 3 years of the study. Similarly, the daily steps of adolescents were decreased, whereas the sedentary behavior of both genders on weekdays was decreased over the 3 years. This decrease of the daily steps may result from the environment around the neighborhoods in which the participants reside. Ding et al. (2011) reported positive associations between neighborhood environment and physical activity among youths. The neighborhood environment in the coastal area catastrophically damaged by the tsunami continues to undergo repair, which could make the neighborhood less favorable for physical activities. In addition, some students may have poor neighborhood environments due to living in temporary dwellings. The schools survived the tsunami because the buildings were located on a hill. Therefore, it seemed that it was important for children and adolescent girls to ensure performing physical activity at an appropriate time in school owing to a significant decrease in their daily steps on weekdays.

To meet current physical activity guidelines (Ganley et al., 2011; World Health Organization, 2010) for children and adolescents to accumulate a minimum of 60 min of moderate-to-vigorous physical activity, Tudor-Locke et al. (2011) recommended 13,000; 11,000; and 10,000 steps per day for boys (aged 6–11 years), girls (aged 6–11 years), and adolescents of both genders (aged 12–19 years), respectively. Another study (Adams et al., 2013) recommended 11,500 accelerometer-determined daily steps for youths and both genders. At 3 years after the earthquake, the median steps of the children and adolescents in this study were lower than these guidelines.

There are few studies about the daily steps of Japanese children and adolescents during the pre-disaster period. For example, one cross-sectional study (Sasayama et al., 2009) reported an accelerometer-determined mean daily steps of Japanese children aged 9–10 years ($n = 288$) on both weekday (Boys: 18,333 ± 3869 steps; Girls: 13,957 ± 2970 steps) and weekend (Boys: 11,932 ± 4827; Girls: 9767 ± 4542). Another study (Sasayama and Adachi, 2011) reported the mean daily steps of Japanese adolescents aged 12–15 years ($n = 314$) on both weekday (Boys: 13,772 ± 4764; Girls: 11,209 ± 2636) and weekend (Boys: 8311 ± 4743; Girls: 7159 ± 3338). In comparison with those in the previous studies, the mean daily steps in children and adolescents living in an area affected by the disaster are considered to be lower. Particularly, the mean daily steps of children of both genders on weekdays at periods IV in the present study were approximately 6500 steps lower than those of the previous study.

In this study, the data was collected from a serial prevalence study. The cause and effect relationship of changes in physical activity is not clear. Future research should elucidate longitudinal demographic and sociocultural factors that contribute to changes in physical activity and sedentary behavior among children and adolescents living in the damaged coastal area. Furthermore, time spent sitting was determined based on the responses to an item in the self-administered questionnaire. Certainly, it may be somewhat difficult for children and adolescents to recall their sedentary time. However, even in a situation of a limited methodology, such as that of an earthquake disaster, we need to evaluate physical activity for health promotion. It seemed to be important to report sedentary time using a self-administered questionnaire for comparison with data for a current or future disaster.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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