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

Kanzo Okazaki a,⁎, Koya Suzuki b, Yuzuru Sakamoto a, Keiji Sasaki a

a Department of Human Science, Faculty of Liberal Arts, Tohoku Gakuin University, Miyagi, Japan
b Faculty of Health and Sports Science, Juntendo University, Chiba, Japan

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.

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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

http://dx.doi.org/10.1016/j.pmedr.2015.08.010
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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  | n.s. |
|----------------------|-----|-----|------|-----|------|
| Girl, n (%)          | 108 (54) | 108 (54) | 82 (55) | 57 (52) |      |
| Grade, n (%)         | 4th  | 65 (33) | 65 (33) | 45 (31) | 38 (33) | n.s. |
| Body mass index, n (%) | Normal  | 106 (83) | 127 (84) | 87 (81) | 78 (81) | n.s. |
| Physical activity of HBSC, n (%)  |            |            |            |            |      |
| Boys                 | Girls   | Girls   | Girls   | Girls   | Girls   |
| 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 |         |
| Steps per day        |         |         |         |         |         |
| Boys                 |         |         |         |         |         |
| Weekday              |         |         |         |         |         |
| 25 percent tile      | 366     | 336     | 227     | 179     |         |
| 50 percent tile      | 550     | 586     | 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 |         |
| Girls                |         |         |         |         |         |
| Weekday              |         |         |         |         |         |
| 25 percent tile      | 11,209  | 9200    | 9627    | 8870    | ** I > IV |
| 50 percent tile      | 12,920  | 11,171  | 11,773  | 10,854  |         |
| 75 percent tile      | 15,297  | 14,773  | 14,971  | 14,775  |         |
| Mean ± SD            | 13,582 ± 3733 | 12,138 ± 4447 | 13,905 ± 4701 | 11,765 ± 4302 | ** I > II, IV |
| Weekend              |         |         |         |         |         |
| 25 percent tile      | 5925    | 4205    | 3751    | 5066    | * n.s.  |
| 50 percent tile      | 9698    | 6467    | 6510    | 7951    |         |
| 75 percent tile      | 12,912  | 10,628  | 12,890  | 11,270  |         |
| Mean ± SD            | 10,128 ± 5278 | 8240 ± 5288 | 9292 ± 7965 | 8501 ± 5060 | ** I > II, IV |
| Steps per day        |         |         |         |         |         |
| Girls                |         |         |         |         |         |
| Weekday              |         |         |         |         |         |
| 25 percent tile      | 7362    | 6780    | 7227    | 5947    | *** I, III > II, IV |
| 50 percent tile      | 8529    | 7836    | 8955    | 7475    |         |
| 75 percent tile      | 9846    | 8925    | 11,066  | 8507    |         |
| Mean ± SD            | 8765 ± 1976 | 7913 ± 1767 | 9302 ± 2985 | 7609 ± 2382 | ** I > II, IV |
| Weekend              |         |         |         |         |         |
| 25 percent tile      | 4950    | 3049    | 3692    | 2769    | *** I, 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 | *** I > II, IV |

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 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.

Acknowledgment

The work of this study was supported by JSPS KAKENHI Grant Number 26750323 and 24680065.

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