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Change in walking steps and association with built environments during the COVID-19 state of emergency: A longitudinal comparison with the first half of 2019 in Yokohama, Japan

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ABSTRACT

In Japan, a state of emergency (SoE) was declared in early April 2020 until late May in response to the first wave of the coronavirus disease (COVID-19). This longitudinal study analyzed the step counts of 18,817 citizens in Yokohama city in the first half of 2020 compared to the previous year, and investigated the association between the change in step counts and the individuals' neighborhood environment by sex and age using generalized linear mixed models. Step counts decreased especially in women and non-elderly people during the SoE. Older women were more susceptible to the neighborhood environment: high walkability (i.e., high population density, proximity to railway stations) adversely affected their step counts, whereas proximity to large parks came to have a positive effect during the SoE.

1. Introduction

In response to the first wave of the coronavirus disease (COVID-19), the then prime minister of Japan declared a state of emergency (SoE) on April 7, 2020. A "soft lockdown" was enforced in Japan until the SoE was lifted on May 25, 2020. Unlike the "hard" lockdown restrictions in other countries that forced people to stay at home or ordered businesses to close, the SoE in Japan tried to promote voluntary infection prevention relying on people's self-restraint and self-defense consciousness (Sposito, 2020). The public sought to avoid the "three Cs" (confined and crowded spaces, and close human contact) and fortunately avoided the first wave, with fewer deaths than in other countries despite the SoE carrying no penalty, crowded public transportation, and the world's oldest population (Sturmer and Asada, 2020). This was largely due to voluntary changes in behavior by citizens, not policies of the national or local government (Hiroi, 2020; Watanabe and Yabu, 2020).

The number of people visiting the major railway stations decreased. For example, the number of people visiting Yokohama Station, which had the largest number of passengers (2.3 million a day in 2017) in Yokohama city, was about 20%–40% during the SoE compared to the same month of the previous year (Cabinet Secretariat, 2020; Ministry of Land Infrastructure Transport and Tourism, n.d.). Companies encouraged employees to work from home, and schools were temporarily

closed from March 2020, causing people to spend more time at home and in their immediate neighborhood. Thus, neighborhood parks became great destinations for those who wanted to exercise during the SoE. The national and local governments were urged to announce infection control measures, such as securing a certain distance between users and using at less crowded times (Ministry of Health Labour and Welfare, 2020; Yokohama City, 2020). According to a national government survey, the percentage of people who chose their neighborhood as the place for a walk or light exercise increased from 60% before the pandemic to 72% during the SoE (Ministry of Land Infrastructure Transport and Tourism, 2020). This indicates the increasing importance of a neighboring built environment (BE) during the SoE. Although many studies have reported an association between BE and physical activity (PA) (Feuillet et al., 2016; Frank et al., 2019; Wasfi et al., 2016), the association may have changed during the SoE.

More PA and less sedentary behavior (SB) are encouraged to reduce the risk of cardiovascular diseases (Carbone et al., 2020; Lavie et al., 2019), and their importance is greater than ever in the COVID-19 era (Arena and Lavie, 2020; Laddu et al., 2020). However, previous studies reported a decrease in PA and an increase in SB during the COVID-19 pandemic (Ghram et al., 2020; Sañudo et al., 2020; Zheng et al., 2020). Older people are at a particularly high risk of decreased PA and increased SB (Browne et al., 2020; K. Yamada et al., 2020; M. Yamada

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et al., 2020a). Decrease in PA is a serious problem that also adversely affects mental health (Colley et al., 2020; Huckins et al., 2020; Jiménez-Pavón et al., 2020; Sato et al., 2020). This decline in PA also occurred in Japan, although it was relatively smaller than that in other countries (Tison et al., 2020). However, only a few studies have examined the moderating effect of the BE on the association between the pandemic and PA. In a study of young Canadians, low residential density and good access to parks were associated with increased outdoor activities (Mitra et al., 2020). During the SoE in Japan, residents in large metropolitan areas spent less time outdoors, although population density was not significantly associated with the time spent outdoors (Hanibuchi et al., 2020). These two studies were based on cross-sectional questionnaire surveys. A prospective study in Croatia showed that adolescents living in urban environments had a larger decrease in PA levels than those living in rural areas, but it only roughly classified the environment (urban or rural). Thus, the relationship between objectively measured PA changes and neighborhood BE resulting from restrictions for COVID-19 has not been sufficiently studied.

The purpose of this longitudinal study was to analyze the fluctuation of the step counts of 18,817 citizens in Yokohama city, Japan, in the first half of 2020 compared to the previous year, and to investigate the association between the change in step counts and their neighborhood environment by sex and age subgroups. Our research questions were: (1) How did the fluctuation of step counts during the SoE differ by sex and age? (2) Did the change in step counts differ by neighborhood BE (i.e., population density, distance to the nearest railway stations, and distance to the nearest large parks)? We used step counts because walking is the most common PA among people worldwide and is one of the most important contributors to total PA (Bélanger et al., 2011). This study is unique in examining the impact of policies different from those of other countries on PA, and the moderating effect of BE on the impact. This study is also unique in that it is longitudinal in design and used objectively measured step counts from a large sample.

2. Materials and methods

2.1. Target area

The target area of this study was Yokohama, the second most populous city in Japan, with a population of approximately 3.75 million people (as of April 2020). Situated 30–40 km from Tokyo, the city's railway network has been developed with many lines toward central Tokyo and comprises 157 railway stations. It was one of the designated venues for the postponed 2020 Olympic and Paralympic Games and was registered as a host town for nine countries. In early February 2020, the cruise ship *Diamond Princess*, carrying many infected passengers, arrived at the Yokohama port. This attracted attention both in Japan and abroad and made Yokohama citizens uneasy.

2.2. Step count data

Step count data were obtained from participants of the Yokohama Walking Point Program (YWPP), launched by the city authority in November 2014 to encourage citizens to adopt measures that could improve their health and healthy life expectancy. The program provided free pedometers (Omron HJ-326F, Japan) for adult volunteers (aged ≥ 18 years) who lived and/or worked in Yokohama. Therefore, we selected Yokohama city as the target area, since large-sample data were not available in other Japanese cities. Participants were awarded points on the basis of their step counts by scanning their pedometers via special readers that were installed at stores and other facilities in the city. The accumulation of a certain number of points made participants eligible to win prizes (4000 steps per day were enough if they wore the pedometers daily). The scanned data were sent to a data server through the Internet, allowing participants to monitor their step counts and rank among all the participants using a computer or smartphone. We used the data

obtained for the first half of 2019 and 2020. Based on an agreement with the city, data on the number of days with records and total step counts were provided monthly in 2019 and weekly in 2020.

We selected the sample for the present study from among 306,770 YWPP participants (as of June 30, 2020). We excluded participants with records for < 20 days in any month between January and June 2019, or < 5 days in any week between January 6, and June 28, 2020 to obtain reliable statistical results, which reduced the sample to 19,094 participants. Furthermore, we excluded 589 participants whose addresses were outside Yokohama city. A total of 18,817 participants were selected as the study sample. We termed them “diligent participants” because they were motivated to have pedometers and to send their step count records frequently. In fact, the step counts of these selected participants were higher than other participants by 1671 step/day in January 2019, for example.

2.3. Quantification of a built environment

Three BE variables were computed for each participant's neighborhood (postal code area) using ArcMap 10.6 (Esri, Redlands, CA, USA), and participants were classified into tertiles for each BE variable. First, we calculated the population density (per hectare) from the population census conducted in 2015. It is high in the area adjacent to Yokohama port, and low in the southern and midwestern parts of the city where few railway stations are located (Fig. 1). Population density ensures local shops and services are more viable, serves as a proxy variable showing the convenience of walking for residents, and is positively associated with walking activity (Hirsch et al., 2014; Koohsari et al., 2017; Troped et al., 2017; Udell et al., 2014). However, because crowded situations are more likely to occur and the risk of close human contact is high, we hypothesized that participants' step counts were likely to decrease in high-density neighborhoods, because people would tend to avoid the risk of close contact.

Second, the average distance to the nearest railway station (in meters) was calculated using data from the National Land Numerical Information download service (Ministry of Land Infrastructure Transport and Tourism, n.d.). As the precise address of each participant was unknown, the distance to the nearest railway station from each participant's address was computed by measuring the distance from the 50-m grid points within the residential sites of each neighborhood to calculate the average for each neighborhood. Access to public transit is positively associated with walking activity (Barnett et al., 2017; Knuiman et al., 2014; Nyunt et al., 2015; Todd et al., 2016). In Yokohama, railway stations host a comprehensive set of services and products, and thereby, serve as destinations that are frequented by residents. However, this increases the likelihood of crowding around railway stations and close human contact is unavoidable on the train. Therefore, we hypothesized that step counts would be likely to decrease in the vicinity of railway stations.

Third, the average distance to the nearest park (m) was calculated using data from the National Land Numerical Information download service (Ministry of Land Infrastructure Transport and Tourism, n.d.) using the same methodology as for measuring distance to the nearest railway station. Although access to parks is associated with PA (Barnett et al., 2017; Brown et al., 2017; Cerin et al., 2018; Lee et al., 2018), we calculated the distance to parks with an area of 1 ha or more because one large park is more effective than numerous small parks in promoting recreational walking (Sugiyama et al., 2015). Many large parks are located in Tsuzuki Ward in the northern part of the city and Kanazawa Ward in the southeastern part of the city. As mentioned in the introduction, parks are one of the urban facilities that was used more during the SoE. Therefore, we hypothesized that participants living near large parks would not decrease their step counts, because they could exercise there.

In previous studies that used step count data of YWPP participants (Hino et al., 2019, 2020), population density and average distance to the

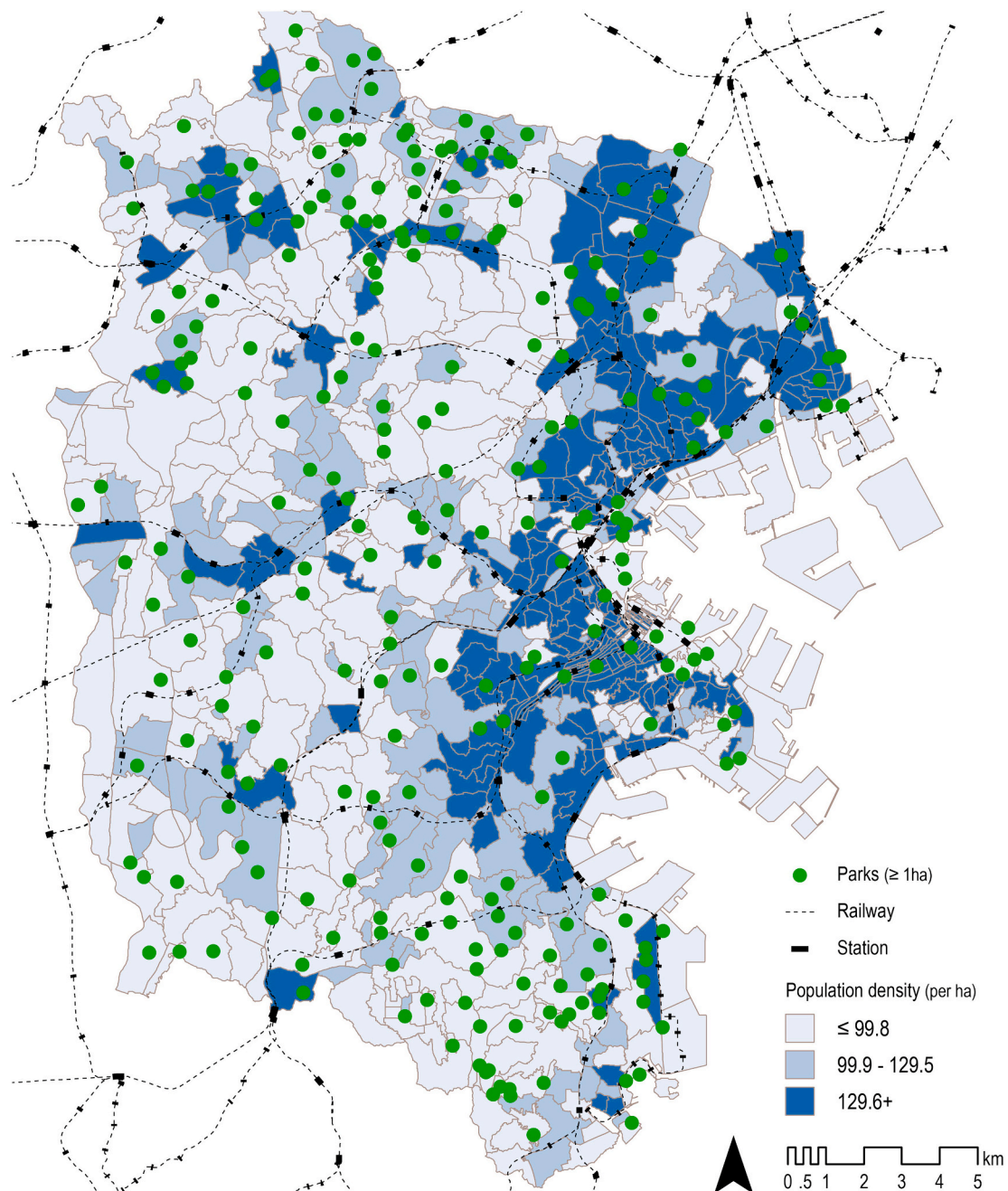


Fig. 1. Target area (Yokohama City).

nearest railway station were associated with participants' step counts, whereas distance to the nearest park did not show an association in any sex or age subgroup, which is not consistent with the above-mentioned previous studies and shows the uniqueness of our study participants.

2.4. Statistical analysis

Participants were categorized into four subgroups according to sex (male or female) and age (younger or older). Older and younger participants were divided by the age of 65 years (as of March 2020). This age is the threshold for older individuals in the Japanese long-term care insurance system, and the employment rate decreases most at this age (Cabinet Office, 2020). We considered that older people, who are more likely to be seriously affected by COVID-19, would be more cautious about going out.

First, we examined the fluctuation of step counts per day from the second week to the 26th week of 2020 compared to the same month of the previous year (year-on-year ratio) using a one-sample Wilcoxon signed rank test against a hypothetical median of 1 because the data were not normally distributed according to the Shapiro-Wilk test. When a week spanned 2 months, it belonged to the month with more days. We compared participants' step counts with those in the same month of the previous year, as a previous study in Yokohama showed a clear seasonal difference in step counts (Hino et al., 2017). Weekly precipitation, obtained from the Japan Meteorological Agency (Japan Meteorological Agency, n.d.), was also taken into account because rainfall affects PA (Delclòs-Alió et al., 2020; Wu et al., 2017).

Next, we examined whether BE factors were associated with the change in the step counts per day during the SoE (weeks 15–21 of 2020) compared to those in April and May of the previous year using

generalized linear mixed models (GLMM) with a Poisson distribution with a log link function. The models had participants' step counts as the outcome variable; days with records as an offset variable; sex, age (younger or older), BE variable, year (2019 or 2020), and their four-way interaction terms as fixed effects; and individuals as a random effect. Three models were run for three BE variables. Neighborhood was not included as a random effect due to the small intraclass correlation (less than 0.01). The association between the change in the step counts and BE was evaluated by the coefficients of the GLMM. In addition, we examined whether the association of BE with the two-year change in step counts differed across the four sex-age subgroups.

Finally, focusing on the subgroup in which the interaction effect of the BE and year was observed among the four subgroups, we more closely examined the association between BE factors and the change in the step counts with respect to week using a similar GLMM, where we compared step counts per day in the 2nd to 26th week of 2020 to those in the same month of the previous year. The significance level was set at $p < 0.05$. All statistical analyses were conducted using IBM SPSS Statistics 26 (IBM Corp., Armonk, NY, USA).

3. Results

3.1. Study participants and their step counts

The characteristics of the study participants and the median and quartiles of their step counts are shown in Table 1. The ratio of men to women was almost the same, and the older individuals accounted for more than 60% of the study participants. The average age was 53.9 ± 7.7 years for the younger and 73.1 ± 5.3 years for the older subgroups. The median step counts in April 2019 and May 2019 tended to be higher in neighborhoods with higher population density and in those nearer to the railway station.

Table 1
Median and quartiles of study participants' step counts.

		n	%	Jan–Jun 2019	w2 - w26
				(Median [1st & 3rd quartiles])	
Sex	Female	9083	48%	6871 (5315,8860)	6332 (4727,8372)
	Male	9734	52%	8926 (6806,11461)	8419 (6265,11063)
Age	Younger (<65)	6781	36%	8370 (6503,10666)	7676 (5781,10010)
	Older (≥65)	12036	64%	7537 (5620,10100)	7164 (5109,9825)
Population density (per hectare)	G1: ≤99.8	6298	33%	7729 (5734,10232)	7322 (5250,9845)
	G2: 99.9–129.5	6270	33%	7802 (5895,10266)	7271 (5300,9763)
	G3: 129.6+	6249	33%	8045 (6107,10456)	7461 (5525,10032)
Distance to the nearest railway station (m)	G1: ≤610.3	6319	34%	8026 (6085,10480)	7522 (5490,10118)
	G2: 610.4–994.2	6241	33%	7875 (5924,10256)	7284 (5334,9764)
	G3: 994.4+	6257	33%	7728 (5721,10203)	7254 (5245,9757)
Distance to the nearest large park (m)	G1: ≤457.1	6288	33%	7907 (5973,10309)	7419 (5501,9905)
	G2: 457.2–674.7	6321	34%	7894 (5943,10373)	7355 (5332,9901)
	G3: 674.8+	6208	33%	7793 (5801,10320)	7276 (5242,9887)
Total		18817	100%	7876 (5911,10335)	7355 (5357,9899)

Participants were classified into tertiles (G1-G3) for each built environment variable.
w2-26: weeks between January 6, and June 28, 2020. G1-G3: groups 1–3.

3.2. Fluctuations in the year-on-year ratio of step counts in the first half of 2020

Fluctuations in the year-on-year ratio of step counts in the first half of 2020 by sex-age subgroups are shown in Fig. 2, plotted with weekly precipitation. Weeks 15–21 were approximately equivalent to the SoE period. Week 12 included three consecutive holidays, and weeks 18 and 19 (the Golden Week) included several holidays. During the SoE, the year-on-year ratio decreased more for the younger than for the older participants, and for women than for men. In particular, the step counts of younger women decreased to <80% of the previous year, and even after the SoE, these step counts recovered only to about 90%–95% of the previous year. According to the Wilcoxon signed-rank test, all subgroups had significantly fewer steps than the previous year after week 9, except for older men in weeks 12 and 23.

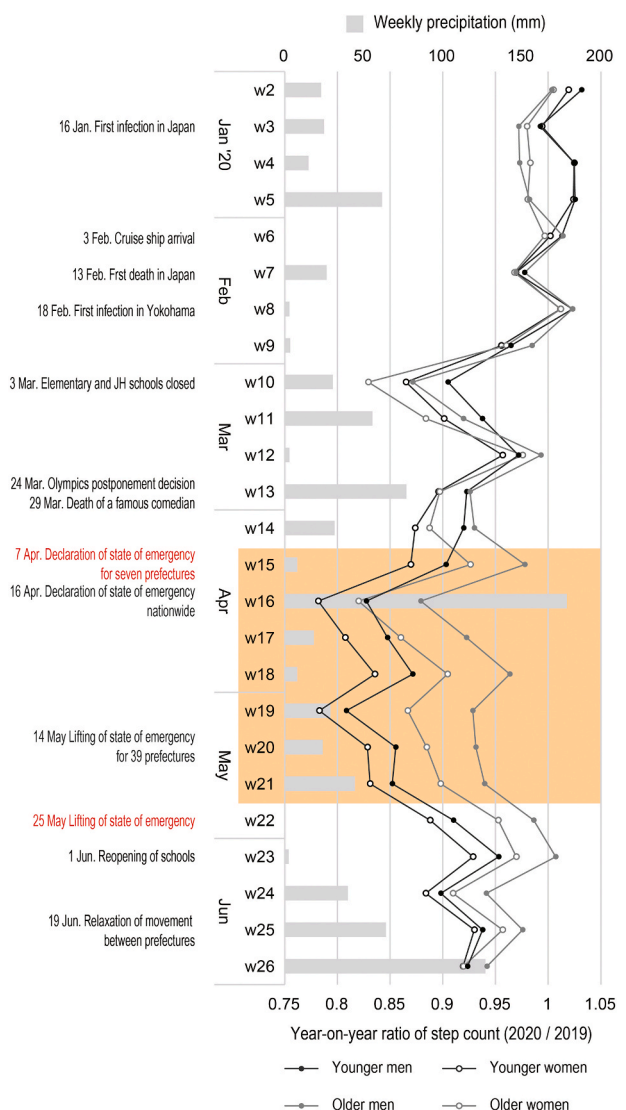


Fig. 2. Fluctuations in the year-on-year ratio of step counts in the first half of 2020. The year-on-year ratio is the ratio of step counts per day from the second week to the 26th week of 2020 to those in the same month of the previous year. JH: junior high; w: week.

3.3. Association between change in step count and built environment during the SoE

As shown in Fig. 3, the estimated coefficients of GLMM, calculated with reference to male sex × older age × G3 × 2019, were used to evaluate the association between the change in the step counts and each of the 3 BE variables. First, the population density was significantly associated with step counts in 2019 in younger women and older men; they walked the most in G3 (high density) neighborhoods (Fig. 3a and

Table S1). The interaction term between the population density and year was only significant in older women; the coefficient of G3 (0.674) was as low as that of G1 (low density; 0.673) and G2 (middle density; 0.667) in 2020. Second, the distance to railway stations was significantly associated with step counts in 2019 in younger women and older men; they walked the most in G1 (short distance) neighborhoods (Fig. 3b). The interaction term between the distance to railway stations and year was only significant in older women; the coefficient of G1 (0.698) was as low as that of G3 (long distance; 0.702) in 2020. Third, the distance to large parks was not significantly associated with step counts in 2019 in any subgroup (Fig. 3c). However, the interaction term between the distance to large parks and year was only significant in older women; the coefficient of G1 (short distance; 0.703) was almost significantly higher than that of G3 (long distance; 0.672) in 2020. Thus, the interaction terms between each of the three BE variables and year were significant in older women.

3.4. Association between change in older women's step count and built environment in the first half 2020 with respect to week

Focusing on older women whose change in step counts differed by neighborhood BE in the previous analysis, we investigated the association between BE and the change in step counts with respect to week. The estimated coefficients of GLMM, calculated with reference to G3 × 2019, were used to evaluate the association, as shown in Fig. 4. First, looking at the population density (Fig. 4a), the coefficient of G3 (high density) was higher than that of G1 and G2 (low and medium) from the beginning of 2020; the difference between G3 and G1 was the largest in week 2 (1.018 and 0.978), while there was almost no difference from week 14 (a week before the SoE declaration). The p-values of population density and their interaction term with year were consecutively significant between weeks 14–24 (three weeks after the end of the SoE); this showed the difference in the association between BE and change in step count (i.e., the moderating effect of BE on the association between time and step count) (Table S2). After week 25, the p-values of the interaction term were again non-significant, with G3 higher than G1 and G2.

Second, focusing on distance to nearest railway stations (Fig. 4b), the coefficient of G1 (short distance) was higher than that of G2 and G3 (medium and long) from the beginning of 2020; the difference between G1 and G3 was maximal in week 4 (1.007 and 0.973), while the difference gradually narrowed and G3 was highest in the 14th week (a week before the SoE declaration). The p-values of distance to the nearest railway station and their interaction term with year were consecutively significant from as early as week 6 (nine weeks before the SoE declaration) to 24 (three weeks after the end of the SoE), except for one week (Table S3). After week 25, the p-values of the interaction term were again non-significant, with G1 higher than G2 and G3. Third, regarding distance to the nearest large park (Fig. 4c), there was almost no difference between the coefficient of G1 (short distance) and that of other groups (medium and long) before the SoE declaration, while the difference gradually expanded and G1 was highest until the end of our study period. The difference between G1 and G3 was the largest in week 18 (0.958 and 0.907). The p-values of distance to the nearest large park and their interaction term with year were consecutively significant from weeks 12 (three weeks before the SoE declaration) to 26 (the end of our study period) (Table S4). It should also be noted that the p-values of the main effect of distance to the nearest large park were consistently non-significant.

The results for other sex-age subgroups are shown in Supplementary Tables S2–S4. In addition to the subgroup of older women, the interaction terms between each BE variable and year were significant in younger women for several weeks during and after the SoE.

4. Discussion

This study first analyzed the fluctuation of step counts among

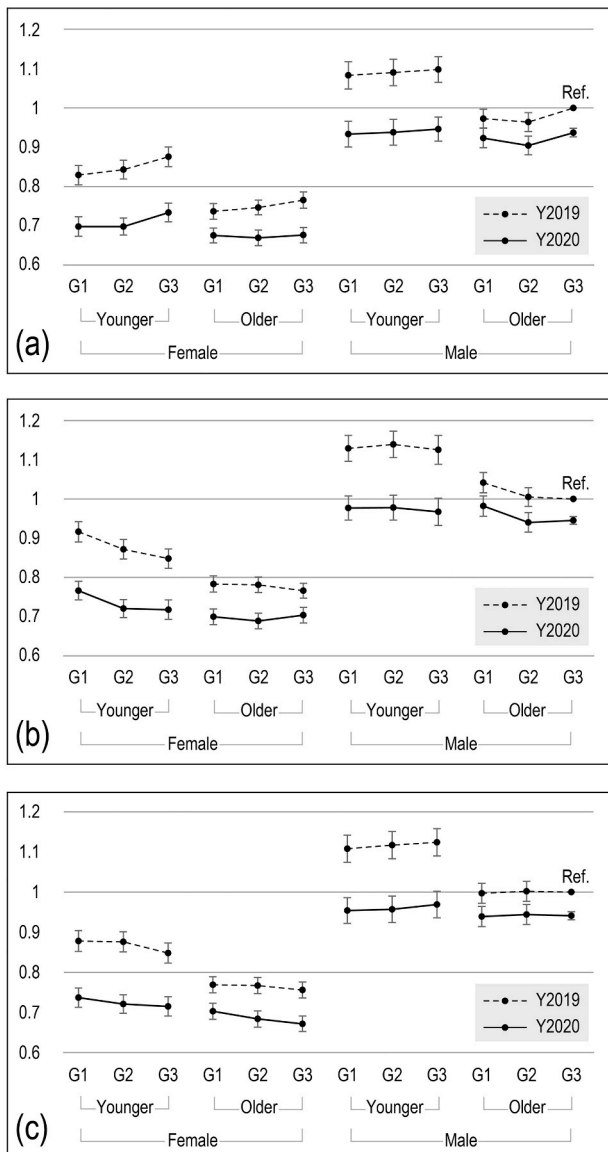


Fig. 3. Coefficients of generalized linear mixed models for step count by sex, age, built environment, and year.

The coefficients in the figure (exponentially transformed) represent the proportional difference between the step counts of a specific sex-age subgroup, level of BE and year, and the step count observed in 2019 among older males living in a neighborhood with the third tertile of each BE (male sex × older age × G3 × 2019).

(a) Population density [per hectare]. G1: ≤ 99.8, G2: 99.9–129.5, G3: 129.6+.

(b) Distance to the nearest railway station [m]. G1: ≤ 610.3, G2: 610.4–994.2, G3: 994.3+.

(c) Distance to the nearest large park [m]. G1: ≤ 457.1, G2: 457.2–674.7, G3: 674.8+.

Y2019: April and May, 2019. Y2020: Weeks 15–21 of 2020 (the period of the state of emergency).

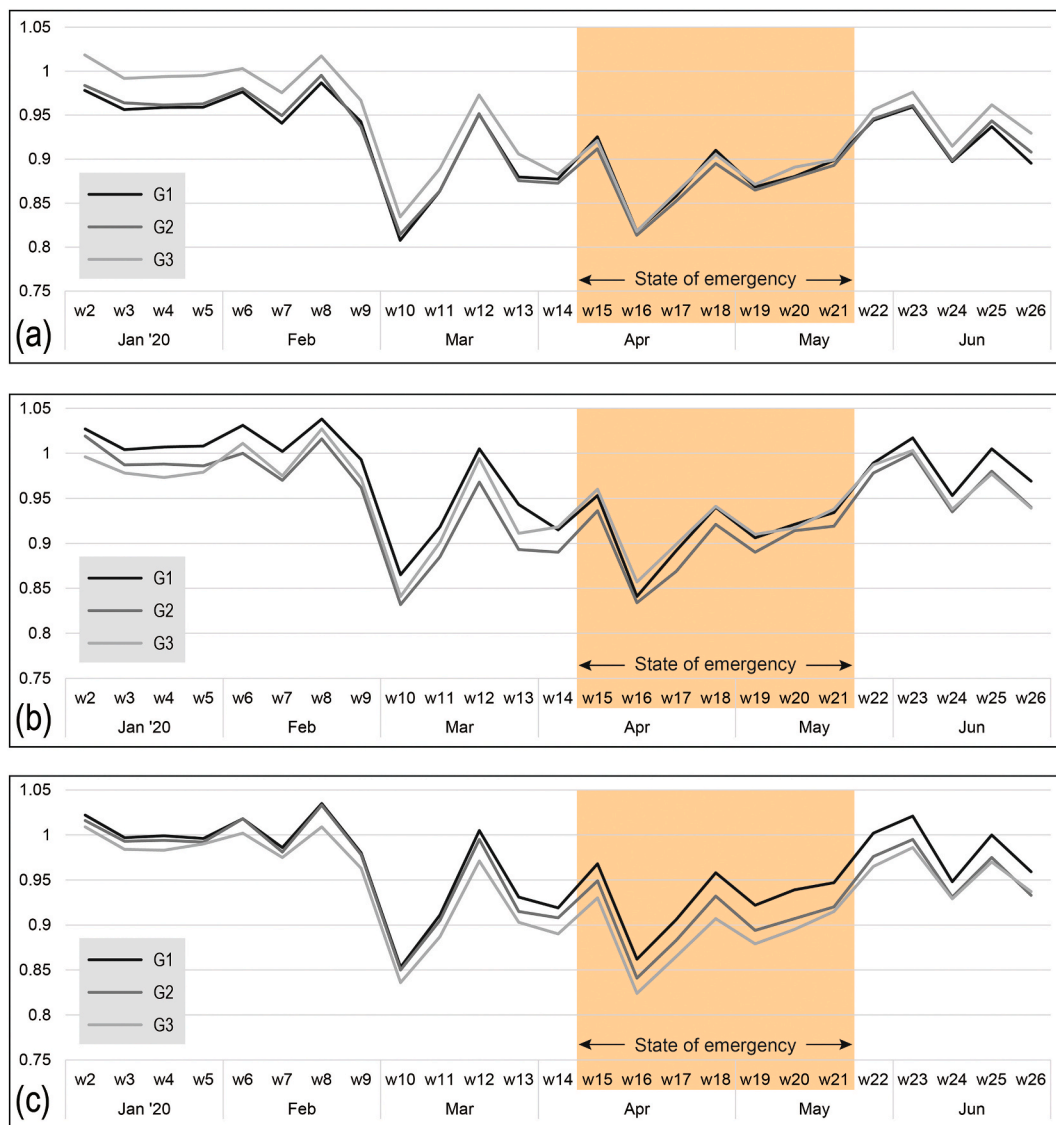


Fig. 4. Weekly coefficients of generalized linear mixed models for older women’s step count by built environment in the first half of 2020. The coefficients in the figure (exponentially transformed) represent the proportional difference between the step counts of a specific level of BE and week, and the step count observed in the same month of 2019 in a neighborhood with the third tertile of each BE (G3 × 2019).
 (a) Population density [per hectare]. G1: ≤ 99.8, G2: 99.9–129.5, G3: 129.6+.
 (b) Distance to the nearest railway station [m]. G1: ≤ 610.3, G2: 610.4–994.2, G3: 994.3+.
 (c) Distance to the nearest large park [m]. G1: ≤ 457.1, G2: 457.2–674.7, G3: 674.8+.

citizens of Yokohama city in the first half of 2020, compared to those of the previous year. The year-on-year ratio of step counts began decreasing in week 9 (February 24, to March 1, 2020), six weeks earlier than the declaration of the SoE, and even at the end of June 2020, it did not return to the previous year’s level. The results of this study are consistent with those of previous studies in that PA began to decrease before the lockdown, but not in that PA began to increase before the lockdown was lifted (Bourdas and Zacharakis, 2020; Pépin et al., 2020; Tison et al., 2020). The answer to the first research question was that there was a sex and age difference in the fluctuation of step counts during the SoE: the year-on-year ratio decreased more in the younger than in the older participants, and in women than in men. The greater decrease in younger participants may be linked to the reduced frequency of commuting due to the recommendation to work from home. This contradicts the finding in China that older adults, in particular, reduced their steps (Wang et al., 2020), indicating international differences in the response to COVID-19. The greater decrease in female participants may be due to a reduced frequency of shopping, in which women often

play the preponderant role for their families. As for the older individuals, men tend to exercise alone, whereas women tend to exercise in groups, and most salon users are also women (Imahori et al., 2016). With the spread of COVID-19, refraining from group activities and the closure of salons may have affected the step counts’ decrease in women. It should be noted that these undesirable behavioral changes may continue even after recovery from the COVID-19 pandemic (Hall et al., 2020).

This study then examined whether the association between the two-year change in step counts and neighborhood BE differed across the four sex-age subgroups. The answer to the second research question is that the change in step counts differed depending on the neighborhood BE. Step count decreased more in neighborhoods with higher population density and shorter distance to railway stations, which are generally considered to be walkable. These BE factors had a greater impact on older rather than younger participants, perhaps because older individuals generally spend more time at/around their home (Kerr et al., 2012; Kim and Ulfarsson, 2015) and they are more prudent because of

their higher risk of being seriously affected by COVID-19 (Liu et al., 2020). In addition, the shorter distance to large parks, which had not been associated with step counts in the previous year, mitigated the decrease. These findings are in line with our hypotheses: people may avoid densely populated neighborhoods, facilities around railway stations, and confined and crowded trains because of the high risk of close human contact. On the other hand, large parks, which are open spaces with a relatively low risk, may have a greater impact on step counts by making it possible to limit the lack of exercise caused by the decreased frequency of going out. In particular, an association between distance to large parks and change in step count was found only in older women. This may indicate that the number of people who gave up group activities at salons and other community facilities and started walking alone in the park increased. Older people may remain socially inactive, even when their PA recovers (M. Yamada et al., 2020b). Given the benefits of exercising in groups, health promotion practitioners need to pay close attention to this phenomenon (Hayashi et al., 2018; McAuley et al., 2000).

Like other metropolitan areas, Yokohama City has been promoting transit-oriented development with high-rise apartments built around major railway stations, and the developed local bus network ensures that approximately 90% of residents can access railway stations in <15 min (Yokohama City, 2014). However, in this pandemic situation, citizens are worried about using confined residential elevators and crowded public transportation. The existence of spacious outdoor open spaces has become more important (Ministry of Land Infrastructure Transport and Tourism, 2020). Although it is unknown how long COVID-19 will continue to affect our consciousness and behavior, urban planners should take this opportunity to rethink the vision of a city with appropriate density and open spaces.

This study makes an important contribution to existing research on the moderating effect of the BE on PA fluctuation during the COVID-19 pandemic, although it has some limitations. The present study lacked background information about the participants, such as their health and financial status. For example, it was found that municipal wards with lower average income had a lower decrease in social contact than those with higher average income (Yabe et al., 2020). In addition, the models in the present study did not consider the neighborhoods' social environment, such as income and education levels. Although the degree of social segregation in Japanese cities is less than that in Western cities (Fielding, 2004), it may interact with BE and have an effect on participants' step counts. Future studies will need to consider more information about participants and the neighborhoods' social environment. Finally, the "diligent participants" of our study may not be representative of the general population in that they were motivated to have pedometers and to send their step count records frequently, suggesting a greater intention to walk than others. We considered that study participants would be less affected by the BE because of their higher motivation and that the effect of the BE would be underestimated in this study. As a study showed that PA in active older people was more affected (Suzuki et al., 2020), caution needs to be taken in generalizing the results.

5. Conclusions

This longitudinal study analyzed the fluctuation of the step counts of 18,817 citizens in Yokohama city, Japan, in the first half of 2020, compared to the first half of the previous year, and investigated the association between the change in step counts and the neighborhood environment by sex-age subgroups. The year-on-year rate of step counts decreased especially in women and younger people during the SoE. Older women were more susceptible to the neighborhood BE: the groups living in the neighborhoods with the highest population density or nearest to railway stations, which had the highest step counts in the previous year, lost their advantage during the SoE. There was no significant association between distance to large parks and step count in the

previous year, but there was from before to after the SoE. Thus, high walkability adversely affected the step counts of older women, whereas closeness to the park had a positive effect. Urban planners should take this opportunity to rethink the vision of cities with appropriate densities and open spaces.

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Ethics approval

The study protocol was approved by the Ethical Committee of the School of Engineering, The University of Tokyo (approval number KE15-17).

Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.healthplace.2021.102544>.

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