Relationship between the actual fine dust concentration and media exposure that influenced the changes in outdoor activity behavior in South Korea

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The one reason of the decrease of walking time for adults in South Korea among various factors is the sense of fear about fine dust sparked by media reports, which has created a negative perception of fine dust. This study aimed to assess the change in concentration of fine dust, as well as individuals’ walking time and health status, in South Korea, and to investigate the relationship between the media reports on fine dust. Using the national government statistics data, we analyzed the relationship between walking time, concentration of fine dust, and amount of media reports on fine dust. From 2008 to 2017, the average walking time and PM10 levels decreased from 76.17 to 49.47 min and 52 to 45 μg/m³; whereas PM10 media frequency increased from 349 to 9,234. No positive correlation existed between walking time in South Korea and exposure to fine dust. However, media reports on fine dust increased steadily from 2012 and peaked in 2015. The decrease in average walking time in South Korea was due to the negative perception created by the increase in media reports on fine dust, rather than the increase in the actual concentration of fine dust.

Interest in particulate matter (PM) among South Koreans is increasing daily. Concerned with the increase in concentration of fine dust and the resultant deterioration of the health of citizens, the Ministry of Environment of South Korea promulgated enforcement regulations “Special Act on Fine Dust Reduction and Management” in February 20191. The purposes of the regulations are to reduce the emission of fine dust and the product of pollutants, manage the occurrence of such pollution to prevent the hazards associated with fine dust, preserve the atmosphere of the environment in an optimal state, and set up a comfortable living environment.

The argument has been amplified through newspapers, news, and various social media networks as a result of the ‘Fine Dust Emergency Mitigation Measure’, changes in the environment, and changes in the health status of individuals. Therefore, the negative perceptions and inconveniences of the people have increased considerably2. The public’s perception of fine dust is expressed in negative emotional terms, they are expressed together with terms with negative meaning, which are related to government activities3. These invisible risk issues cause citizens to have uncertainties and fears about fine dust itself, and they are as well dependent on the media for information on ways to protect themselves from these invisible risks4.

The National Institute of Environmental Research (NIER) of South Korea announced that fine dust occurs in boilers, automobiles, factor operation facilities, etc., and these sources account for a considerable amount of fine dust measured domestically. That is, a considerable part of fine dust generation can be attributed to domestic factors5. Analysis of the contributions of fine dust domestically and from foreign countries in 2018 by NIER

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Figure 1. Research on composite data using national government statistics. We used a variable factor to analyze the changes in actual fine dust concentration, health behavior, index related health status and frequency of media reports related to fine dust from 2008 to 2017. Republic of Korea Environmental Statistics Yearbook Data for PM (particulate matter) 10 and PM2.5 in Seoul City. Republic of Korea Ministry of Statistics Social Survey Data for awareness of social safety, afraid for night walking. Republic of Korean Ministry of Statistics Korean City and Province Basic Statistics Data for number of park and number of sport site. Republic of Korea Press Foundation is open provide social mass media exposure data in news big data & analysis system for mass media exposure related particulate matter.

revealed that the average foreign contribution constituted about 44–55%, which is different from the 60–80% of high concentration of fine dust known to be contributed by foreign influences8. It is supported by the facts that much of fine dust generation is due to domestic factors that are a continuation of domestic high pressure impact and stagnation of Barometer7, increased direct air pollutant emissions domestically8,9, and difference between measurement sites due to emitted air pollutants cannot move away10 even if high concentration fine dust in the windward area such as Chinese Bohai region formed the inflow route to the South Korea (domestic) by the northwest wind11,12,13.

In the analysis of fine dust-related keywords in “Big Kinds”, a comprehensive news database, provided by the South Korea Press Foundation-News Big Data & Analysis System, some articles with business purposes, such as specific services or household goods, were related with fine dust in spite of media coverage. These articles use short-term strategies from focused on simple interest that are not based on fundamental problem-solving methods, and aimed at increasing the public’s response to fine dust. However, these short-term strategies used in media reports on fine dust, which actually requires a long-term strategy, appear to have negative influences on policy making and the utility14. In one study15 comparing the variation in fine dust concentration in South Korea by air quality evaluation reports16 and the frequency of media reports related to fine dust concurrently, an explosion of media coverage of PM, caused the implementation of the fine dust forecasting system, according to the Ministry of Environment’s revised < the Air Quality Preservation Act > in July 2013. However, no significant association existed between the actual increase in PM. In contemporary societies, the most frequently used model for modeling various social risk factors is the Social Amplification of Risk Framework17. In Kim’s study, the model revealed that public perception of risk phenomenon in modern societies depends on social and cultural characteristics, which can determine the public’s perception and behavior change according to the risk phenomena18. The risk that the public are aware of the fine dust shall be two kinds exist: ‘objective risk’ related to physical damage and ‘subjective risk’ related to the object’s perception, regardless of actual damage14. Especially, since knowledge of the danger of fine dust is transmitted to the public by the media and spread to the public, it is recognized as a ‘subjective risk’ to the public. So the importance of proper media coverage of fine dust is being emphasized.

The purpose of this study was to assess the changes in the actual concentration of fine dust over recent years, analyze the health status related to behavior index of the public, and identification of the risk factors. This research was conducted on the hypothesis that a positive correlation exists between the variation in actual concentration of fine dust during this period and the health status and health-related behavior index of the public. Using the Korea National Nutrition Examination Survey, if the health-related behavior index of the public decreases, it is due to an increase in excess media report on fine dust to understand the relationship between various external, domestic-foreign, urban-environmental, and socio-environmental factors. Based on this research, it is necessary to change the perception of factors that negatively affects public health behavior by creating a fear of fine dust among the public, which is as a result of indiscreet media coverage on fine dust. This study did not only seek to identify the sources of fine dust inflow from outside factors but also to reduce the sources of fine dust by suggesting various possible domestic and external factors. In addition, we hope that it can be used as basic data to emphasize the necessity of comprehensive health promotion and policy support.

Method
Research on composite data using national government statistics. These research data were derived from the national government statistics, which is a merger of data from the National Health and Nutrition Examination Survey, Environmental Statistics Yearbook, Ministry of Statistics Social Survey, Ministry of Economy and Finance, and Press Foundation-News Big Data & Analysis System: The Big Kinds-Mass Media Exposure Data. These data are merged based on city codes of cities in South Korea. This was an ecological model and trends study in the decade from 2008 to 2017 (Fig. 1).
National health and nutrition examination survey data. The National Health and Nutrition Examination Survey\(^9\) is a statutory survey on the health behaviors of the public, current status of chronic diseases, and actual condition of food and nutrition based on Article 16 of the National Health Promotion Act. The data of the National Health and Nutrition Survey of South Korea was collected through the circular sample survey design of the citizens whose subjects themselves could represent South Korea. In addition, when this data is provided to researchers, there is no problem of personal information leakage because the personal information is statistically secured. In other words, there was no problem of research ethics or sampling during analysis. The National Health and Nutrition Examination Survey was conducted every 3 years from the first period (1998) to the third period (2005). Thereafter, it was reorganized as a yearly survey system and was carried out annually during the fourth period (2007–2009). The survey was conducted with the approval of the Research Ethics Review Committee of the Disease Control Division, and the results of the survey were published through the dissemination of press releases, statistical publications, and publication of the original data until December of the next year.

We analyzed the data from 2008–2017. The variables analyzed for the general characteristics were sex, age, household income, education level, occupation group, and subjective health status. To assess health status, data on systolic blood pressure, diastolic blood pressure, body mass index, fasting blood sugar, Hemoglobin A1c (HbA1c), total cholesterol, high-density lipoprotein (HDL) cholesterol, and low-density lipoprotein (LDL) cholesterol were analyzed. The dependent variables were walking level and duration (in minutes). The average walking duration was measured for South Korea and the metropolitan city, Seoul (Fig. 2).

Environmental statistics yearbook data. We used data from the Environmental Statistics Yearbook\(^20\), which included measurements of air quality and PM\(_{10}\) in South Korea. This data control is the based cities code merge the PM\(_{10}\) data in Korea National Health and Nutrition Examination Survey Data cities code. Therefore, average PM\(_{10}\) levels in a decade was calculated for the whole nation. The variables used were PM\(_{10}\) for the whole nation's average and PM\(_{10}\) and PM\(_{2.5}\) for the metropolitan city, Seoul's average.

Ministry of statistics Korea city and province basic statistics data. Data from the Ministry of Korea City & Province Basic Statistics were used\(^1\). The data included the number of parks and sports sites. This variable was used to assess the relationship between the city environment and walking time.

Ministry of statistics social survey data. We used data from the Ministry of Statistics Social Survey\(^22\) to assess safety consciousness and policy making and utilization of basic data for people. The data used included the awareness of social safety and fear of walking at night. The survey is conducted biennially, and the years included for this study were 2008, 2010, 2012, 2014, and 2016. Social safety was summarized using good safety line and bad safety line. The awareness of good social safety was indicated by 'very safe' and 'often safe', whereas the awareness of bad social safety was indicated by 'often not safe' and 'very not safe'.

Press foundation-news big data and analysis system: the big kinds-mass media exposure data. We used Press Foundation is open provide social mass media exposure data in news big data & analysis system: The Big Kinds\(^23\). We searched for information on PM\(_{10}\) mass media exposure using these keywords: 'find dust', 'PM\(_{10}\)', or 'Particulate Matter 10'; These keywords exposure to the South Korea. It's exposure frequency through press company.

Statistical analysis. We used the open source statistical software R version 3.6.0 for all statistical analyses. Descriptive frequencies were used to analyze general characteristics; descriptive statistics to analyze PM\(_{10}\) and PM\(_{2.5}\) Mass Media Exposure Frequency in South Korea and Seoul walking time (in minutes) and Seoul PM\(_{10}\) and Seoul PM\(_{2.5}\) and Social Environment (Number of Park & Number of Sport site), ANOVA post-hoc Scheffe test to the according to decade years. Multiple line charts were used to display the data. Multiple regression analysis was performed to identify factors affecting walking time.

Results

General characteristics. We were subjects total 20,605 persons in National Health and Nutrition Examination Survey decade data. Decade average number of subjects percentages sex were Male 54.1%, Female 46.0%, Age were 20–39 years 28.3%, 40–64 years 52.5%, 65–74 years 14.0%, more than 75 years 5.3%, House-hold income were high groups 28.1%, mid-high groups 27.0%, mid-low groups 26.1%, low groups 18.9%, education level were more than college 31.0%, high school 34.3%, middle school 11.7%, less than elementary school 22.9%, occupation type were non-physical job 36.1%, physical job 27.7%, inoccupation 36.2% and subjective health level were more than college 31.0%, high school 34.3%, middle school 11.7%, less than elementary school 22.9%.

Trends for walking time (minutes), PM\(_{10}\), and PM\(_{2.5}\) mass media exposure frequency in South Korea and walking time (minutes), PM\(_{10}\), and PM\(_{2.5}\) in Seoul City. The average walking time (in minutes) decreased from 76.17 min in 2008 to 49.47 min in 2017. Concurrently, PM\(_{10}\) levels decreased from 52 µg/m\(^3\) in 2008 to 45 µg/m\(^3\) in 2017, but PM\(_{2.5}\) mass media exposure frequency increased from 349 in 2008 to 9734 in 2017 (Fig. 3). Walking time (in days) decreased from 4.53 to 3.75 days in 2017 (Table 2). In Seoul, walking time (in minutes) decreased from 72.83 min in 2008 to 52.88 min in 2017. Concurrently, PM\(_{10}\) levels decreased from 55 µg/m\(^3\) in 2008 to 44 µg/m\(^3\) in 2017. However, the trends for PM\(_{2.5}\) did not change over the
years (Fig. 4); walking time (in days) among Seoul residents repeatedly decreased and increased over the decade (Table 2).

Trends for number of park and number of sport site in South Korea. The number of walking-friendly parks and sport sites increased in the decade from 2008 to 2017. The number of parks increased from 21,579 in 2008 to 49,400 in 201; whereas that of sport sites increased from 24,785 in 2008 to 33,813 in 2017 (Fig. 5).

Trends for awareness of social safety and Afraid for night walk in South Korea. The awareness of social safety was described as either good safety line or bad safety line. Awareness of good social safety line increased whereas that of bad social safety line repeatedly decreased and increased. Trends on fear of walking at night did not change (Fig. 6).
The nation’s budget on health, land, and area development was continuously increased. For health, the budget increased from 41,801 billion won (35 billion dollar) in 2008 to 45,011 billion won (37 billion dollar) in 2017. For land and area development, the budget increased from 64,417 billion won (54 billion dollar) in 2008 to 172,426 billion won (145 billion dollar) in 2017 (Table 3).

Trends for budget of health expenditure and budget of land and area development expenditure in South Korea. The nation’s budget on health, land, and area development was continuously increased. For health, the budget increased from 41,801 billion won (35 billion dollar) in 2008 to 45,011 billion won (37 billion dollar) in 2017. For land and area development, the budget increased from 64,417 billion won (54 billion dollar) in 2008 to 172,426 billion won (145 billion dollar) in 2017 (Table 3).

Trends for health examination in South Korea. Health Examination variables were systolic blood pressure, diastolic blood pressure, body mass index, fasting blood sugar, HbA1c, triglycerides, total cholesterol,
Figure 4. Trends for daily average walk time (Minutes) of in Seoul, Republic of Korea and annual average concentration of PM10 (Particulate Matter 10) in Seoul, Republic of Korea & annual average concentration of PM2.5 (Particulate Matter 2.5) in Seoul, Republic of Korea and frequency of annual average of mass media exposure related PM10 in Republic of Korea from 2008 to 2017. **Blue line.** The daily average walk-time (Minutes) of Seoul, Republic of Korea’s public decreased from 72.83 minutes in 2008 to 52.88 minutes in 2017. **Brown line.** The annual average concentration of PM10 in Seoul, Republic of Korea decreased from 55 μg/m³ in 2008 to 44 μg/m³ in 2017. **Purple line.** The annual average concentration of PM2.5 in Seoul, Republic of Korea not changed at years. **Black line.** The annual average frequency of mass media exposure related to PM10 in Republic of Korea increased from 349 in 2008 to 9,234 in 2017.

| Variable                       | 2008 M (SD) | 2009 M (SD) | 2010 M (SD) | 2011 M (SD) | 2012 M (SD) | 2013 M (SD) | 2014 M (SD) | 2015 M (SD) | 2016 M (SD) | 2017 M (SD) | F (p)           |
|--------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|----------------|
| Walk hour (min)                | 76.17 (99.48) | 71.89 (88.22) | 59.71 (71.61) | 54.62 (54.42) | 57.06 (70.40) | 57.46 (84.41) | 56.38 (74.48) | 53.10 (61.01) | 48.36 (52.22) | 49.47 (61.09) | 106.36 (< .001) |
| Walk day                       | 4.53 (2.59)  | 4.31 (4.31)  | 3.95 (2.64)  | 3.81 (2.59)  | 3.83 (2.62)  | 3.76 (2.63)  | 3.80 (2.43)  | 3.70 (2.43)  | 3.77 (2.43)  | 3.70 (2.43)  | 76.31 (0.06)  |
| Seoul walk hour (min)          | 72.83 (97.21) | 71.80 (80.66) | 64.19 (71.63) | 52.88 (52.96) | 58.46 (58.69) | 54.67 (52.43) | 56.90 (52.68) | 56.90 (52.68) | 52.80 (56.50) | 52.88 (56.50) | 17.02 (0.001)  |
| Seoul walk day                 | 4.59 (2.51)  | 4.44 (2.43)  | 4.22 (2.53)  | 4.14 (2.50)  | 4.32 (2.40)  | 4.17 (2.47)  | 4.00 (2.40)  | 4.00 (2.40)  | 4.00 (2.40)  | 4.00 (2.40)  | 5.73 (0.001)  |

Table 2. Decade years compare of walk hour (min) in Republic of Korea & Seoul walk hour (min). Continuous variables were expressed as M(SD). M: year mean value, SD: standard deviation, ANOVA(F test): post-hoc method: Scheffe. Significant p value: p < .05.

Figure 5. Trends for daily average walk time (Minutes) of Republic of Korea & annual number of Sport site in Republic of Korea and annual number of Park in Republic of Korea from 2008 to 2017. **Blue line.** The daily average walk-time (Minutes) of the Republic of Korea’s public decreased from 76.17 minutes in 2008 to 54.62 minutes in 2011 and decreased steadily to 49.47 minutes in 2017. **Green line.** The annual number of Sport site in Republic of Korea increased 24,785 in 2008 to 33,813 in 2017. **Light green line.** The annual number of Park in Republic of Korea increased 21,579 in 2008 to 49,400 in 2017.
HDL cholesterol, and LDL cholesterol. The average systolic blood pressure increased from 115.83 mmHg in 2008 to 124.13 mmHg in 2017. Diastolic blood pressure also increased from 74.70 mmHg in 2008 to 79.61 mmHg in 2017. Body mass index also increased from 23.61 kg/m² in 2008 to 23.88 kg/m² in 2017. Fasting blood sugar increased from 98.21 mg/dL in 2008 to 100.91 mg/dL in 2017. HbA1c increased from 5.36% in 2008 to 5.66% in 2017. Triglycerides repeatedly decreased or increased from 131.26 mg/dL to 130.28 mg/dL. Total cholesterol increased from 187.74 mg/dL to 211.94 mg/dL. HDL cholesterol decreased from 51.42 mg/dL to 42.18 mg/dL. LDL cholesterol increased from 111.38 mg/dL to 119.87 mg/dL (Table 4). The trends for health examination has been bad in South Korea (Table 4).

Figure 6. Trends for daily average walk time (Minutes) of Republic of Korea & Once response rate every 2 years about Awareness of bad social safety in Republic of Korea & Once response rate every 2 years about Afraid for Night walking in Republic of Korea and Once response rate every 2 years about Awareness of Good social safety in Republic of Korea, included 2008, 2010, 2012, 2014, 2016. Blue line. The daily average walk-time (minutes) of the Republic of Korea’s public decreased from 57.58 minutes in 2008 to 50.38 minutes in 2016. Red line. The response rate about Awareness of Bad social safety in Republic of Korea was decrease and increased repeatedly. Gray line. The response rate about Afraid for night walking not changed. Yellow line. The response rate about Awareness of Good social safety increased 8.2 percent in 2008 to 13.2% in 2016.

| Variable                                      | 2008 Year Mean | 2009 Year Mean | 2010 Year Mean | 2011 Year Mean | 2012 Year Mean | 2013 Year Mean | 2014 Year Mean | 2015 Year Mean | 2016 Year Mean | 2017 Year Mean |
|------------------------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| PM10*                                         | 52             | 51             | 49             | 48             | 43             | 47             | 47             | 47             | 45             | 45             |
| PM10 mass media† exposure frequency            | 349            | 405            | 351            | 287            | 255            | 1,178          | 2,212          | 3,250          | 6,040          | 9,234          |
| Seoul PM10*                                    | 55             | 54             | 49             | 47             | 41             | 44             | 46             | 45             | 48             | 44             |
| Seoul PM2.5*                                   | 26             | 26             | 25             | 24             | 23             | 25             | 24             | 23             | 26             | 25             |
| Number of park†                                 | 21,579         | 23,696         | 26,118         | 28,834         | 31,436         | 34,527         | 37,899         | 43,000         | 46,077         | 49,400         |
| Number of sport site†                          | 24,785         | 25,147         | 26,161         | 27,808         | 28,663         | 29,593         | 31,049         | 32,922         | 33,813         |
| Awareness of good social safety                | 8.2            | –              | 11.3           | –              | 13.8           | –              | 9.5            | –              | 13.2           | –              |
| Awareness of bad social safety                 | 51.4           | –              | 38.5           | –              | 37.3           | –              | 50.9           | –              | 45.5           | –              |
| Afraid for night walking                       | 40.8           | 40.6           | –              | 44.0           | –              | 42.6           | –              | 40.9           | –              | –              |

Table 3. PM10 and PM10 mass media exposure frequency in Republic of Korea and Seoul PM10 and Seoul PM2.5 and social environment in Republic of Korea. *PM10 and PM2.5 unit: μg/m³. †Number of frequent. Awareness of good and bad social safety and afraid night walking-unit: %.

HDL cholesterol, and LDL cholesterol. The average systolic blood pressure increased from 115.83 mmHg in 2008 to 124.13 mmHg in 2017. Diastolic blood pressure also increased from 74.70 mmHg in 2008 to 79.61 mmHg in 2017. Body mass index also increased from 23.61 kg/m² in 2008 to 23.88 kg/m² in 2017. Fasting blood sugar increased from 98.21 mg/dL in 2008 to 100.91 mg/dL in 2017. HbA1c increased from 5.36% in 2008 to 5.66% in 2017. Triglycerides repeatedly decreased or increased from 131.26 mg/dL to 130.28 mg/dL. Total cholesterol increased from 187.74 mg/dL to 211.94 mg/dL. HDL cholesterol decreased from 51.42 mg/dL to 42.18 mg/dL. LDL cholesterol increased from 111.38 mg/dL to 119.87 mg/dL (Table 4). The trends for health status examination has been bad in South Korea (Table 4).

Factor affecting to walk time (min) in South Korea. In order to examine factors affecting walking time, data from 2008 to 2017 were analyzed using multiple regression analysis (step-wise). Variables that can affect walking time in the dataset: PM10, PM10 Mass Media Exposure, Awareness of Good Social Safety, Afraid for night walking, Number of sport site, Number of park, Sex, Age, House-hold income, Education Level, Occupation, and Subjective health state were included. As a result, House-hold income, Occupation, Number of sport site, and Number of park were excluded. As a result of controlling these variables, the walking time decreased by $\beta = -0.022$ as the PM10 increased and $\beta = -0.053$ as the PM10 Mass media exposure increased (Table 5).
Variable & 2008a & 2009b & 2010c & 2011d & 2012e & 2013f & 2014g & 2015h & 2016i & 2017j & F (p) & Scheffe  
--- & --- & --- & --- & --- & --- & --- & --- & --- & --- & --- & --- & ---  
Systole blood pressure & 115.83 (17.26) & 119.17 (16.69) & 119.94 (16.83) & 117.51 (16.80) & 125.13 (16.38) & 123.60 (15.91) & 122.77 (15.14) & 119.14 (17.16) & 124.12 (15.12) & 124.13 (16.28) & 53.181 (< .001) & a < b, c, d, e, f, g, f  
Diastole blood pressure & 74.70 (10.96) & 78.30 (10.59) & 77.92 (10.67) & 76.49 (10.27) & 80.29 (10.85) & 79.25 (11.14) & 78.71 (9.88) & 75.05 (10.17) & 79.67 (10.41) & 79.61 (11.15) & 103.696 (< .001) & a, b, c, d < e, f, g, f  
Body mass index & 23.61 (3.27) & 23.66 (3.34) & 23.57 (3.33) & 23.74 (3.33) & 23.77 (3.38) & 23.66 (3.34) & 23.91 (3.44) & 23.97 (3.51) & 23.88 (3.48) & 156.636 (< .001) & a, b, c, d < e, f, g, f  
Fasting blood sugar & 98.21 (23.40) & 97.39 (21.96) & 97.20 (21.65) & 97.71 (22.29) & 98.48 (21.52) & 98.96 (21.00) & 99.42 (21.92) & 100.87 (24.01) & 101.31 (24.58) & 100.91 (23.63) & 29.067 (< .001) & a, b, c, d, e, f, g, h, i  
HbA1c & 5.36 (1.02) & 5.37 (0.92) & 5.39 (0.99) & 5.68 (0.63) & 5.74 (0.74) & 5.84 (0.74) & 5.75 (0.75) & 5.66 (0.76) & 5.66 (0.57) & 5.66 (0.78) & 156.636 (< .001) & a, b, c < d, e, f, g, h, i  
Triglyceride & 131.26 (93.43) & 131.25 (91.45) & 128.86 (88.15) & 129.84 (88.23) & 128.20 (83.91) & 131.03 (90.39) & 131.12 (90.75) & 132.07 (89.97) & 135.20 (92.51) & 130.28 (87.48) & 2.479 (.008) & c, d, j < a, b, f, g < h, i  
Total cholesterol & 187.74 (36.01) & 186.62 (35.75) & 187.70 (37.17) & 188.73 (36.14) & 208.43 (40.50) & 204.76 (39.77) & 203.96 (37.39) & 190.41 (35.92) & 210.15 (41.570) & 211.94 (42.53) & 99.505 (< .001) & a, b, c, d, e, f, g, h, i  
HDL cholesterol & 51.42 (12.63) & 52.33 (12.66) & 52.89 (12.83) & 53.20 (13.00) & 42.41 (9.21) & 43.84 (9.69) & 43.70 (10.03) & 50.98 (12.97) & 41.95 (10.03) & 42.18 (9.34) & 127.024 (< .001) & a, b, c, d < e, f, g, h, i  
LDL cholesterol & – & 111.38 (31.13) & 112.70 (31.77) & 114.28 (32.80) & 120.41 (35.25) & 114.97 (34.76) & 116.85 (33.59) & 113.79 (31.92) & 117.02 (35.57) & 119.87 (38.14) & 10.243 (< .001) & a, b, c < d, e, f, g, h, i  

Table 4. Decade years compare of health examination in Republic of Korea. Continuous variables were expressed as mean (SD). SD: standard deviation, ANOVA (F test): post-hoc method: Scheffe. Significant p value: p < .05. Systole and diastole blood pressure unit: mmHg, Body Mass Index = Body Weight/(Height)2, Fasting blood sugar and triglyceride and total cholesterol, high density lipoprotein(HDL) cholesterol & Low Density Lipoprotein(LDL) Unit: mg/dl, HbA1c (glycated hemoglobin) Unit: %.

| Variable | Walk time (min) | β | p  |
|----------|-----------------|---|---|
| PM10     | − .022          | .005 |
| PM10 mass media exposure | − .053 | < .001 |
| Awareness of good social safety | − .069 | < .001 |
| Afraid for night walking | − .252 | < .001 |
| Sex—female (ref: male) | − .078 | .001 |
| Age      | − .052          | < .001 |
| Education level | − .057 | < .001 |
| Subjective health state | .047 | < .001 |
| Model fit | R² = .021, F = 71.750, p < .001 |

Table 5. Factor affecting to walk time (min). Multiple regression analysis (step-wise): exclude variable (household income, occupation, number of sport site, number of park). Whole analysis the dataset 2008–2017. β: Standardized coefficient, p: p value.

Discussion
This research was based on the fact that South Korea has a conducive physical environment (number of park, number of sport site, decreased PM10) and a friendly social environment (increased awareness of good social safety, increased budget of health, increased budget of land and area development) for walking. However, in the last decade, the national average time for walking has decreased. From Fig. 3, one would observe that the walking time (minutes) has decreased, whereas the PM10 mass media exposure frequency increased. At the same time, the health status of residents of South Korea have deteriorated according to health examination data, and this has been reasoned to be as a result of the reduction in walking behaviors. The beneficial effects of walking on health include the reduction in systolic blood pressure, diastolic blood pressure, triglycerides, total cholesterol, fasting blood sugar, and HbA1c. Therefore, we presumed that the reduction in walking behaviors among residents of South Korea is as a result of the fear of increased mass exposure to air pollutants, such as PM10, which they

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think may expose them to some forms of danger. But this really factors the decreased PM10 decennary. And South Korea’s Average year PM10 was not danger and many improve the air quality than past 10 years, for the do not walking and do not health benefits. South Korea governments fighting making policy and finance the budget for improve air quality and good for healthy environment & good for social safety environment. This really problem is the press companies over exposure of the mass media output results that it. Examples reference of negative health affect mass media exposure, television and magazine were Internalization of the thin beauty ideal, social comparison, and activation of the thinness schema are clearly among the processes which mediate the effects of the media on body dissatisfaction, weight concerns and disordered eating behaviors. Mass media was not every day positive affect. This influence of particulate matter risk perception in the public is reflected to various type of risk related environmental, social and economics. You et al. said that the large amount of media reports on uncertain basis as the particulate matter frame affects the physical activity of the public. In others studies said that the public is perceived and more reacts about the risk of particulate matter due to increase of media coverage and warning message.

According to data from the Korean National Health and Nutrition Examination survey, the average walking time of people aged above 19 years is decreasing year by year. The reasons for this are the lack of absolute walking time due to long working hours, lack of ecological and suitable urban environment-facility, the amount of health-related budget input for walking in the city or bicycles, and awareness of city safety for living. Furthermore, various studies have reported that economic crisis affects health related behavior, another study in Spain said that it caused health-related behavior changes due to economic-financial crisis. On the other hand, as a result of analyzing changes in the health-related behavior of Greeks due to the financial crisis, physical activity increased in the first economic crisis in 2011. In the case of Korea, the crisis triggered in the US financial market in 2008 spread to the world, and the economic crisis began and continued in Korea. As a result, the psychological burden of the people was increased, consumer life was greatly reduced, and activities in all fields were stagnant. In response to this economic crisis, the public focused on job search and alternative economic activities, showing a decrease in physical activity such as walking. These suggest that the problem is not only a factor of the individual but also a factor of the various ecological backgrounds that can affect the walking time. In our study, walking time decreased in spite of the increase in ecological urban sites and the positive awareness of urban safety. If this is the case, then the cause of the decrease in walking time is likely a factor in the individual perception level. Therefore, the change in perception was attributed to an increase in awareness of the crisis due to increased media reports related to fine dust in this study. A study by Kim et al. conducted a frame analysis and a source analysis of a fine dust reporter to examine the risk perception of fine dust. During the frame analysis, it was found that the amount of articles reported on an uncertain basis was quite large, and the most frequently used experts as sources of information. In addition, Kim et al. said that communication and media studies have a profound effect on the people living in modern times, and that a large amount of articles reported as an uncertain basis during the analysis of the fine dust frame affects people’s physical activities. Also, people are increasingly aware of the dangers of particulate matter due to increased media coverage and warning messages.

PM risk perception is not only a real risk to health, but also a complex phenomenon affecting changes in public opinion and policy. For example, outdoor activity such as walking are limited by the level of particulate matter. The limitation of the outdoor activity brings about the increased in economic burden due to the use of defensive products, such as mask or air filters, and the increase of alternative service to replace the traditional outdoor activity, expansion of indoor activity, such as yoga and weight training. In addition, South Korea is a country with very well-developed Internet and Social networking service and particulate matter risk perception is formed depending on the frequency of media reports regardless of the actual frequency of occurrence and the risk of harm to health. In a summary, South Korea’s particulate matter-related policies should take into account not only economic development but also social point of view.

These type of media report which address above, for example, “The inflow of fine dust from China increased up to 86% as a foreign factor, gave the people a sense of ‘fine dust = China’. However, this was only the result of the analysis of a certain period of China’s influence. In fact, the concentration of fine dust in most areas of China has decreased, but the uncertainty of the increase in fine dust concentration due to the relocation of a specific industrial complex in China has increased the public’s fear about fine dust. Even if it is not solely the risk of fine dust created by media coverage, the media’s influence on perception of risk factors related fine dust cannot be ignored. Previous reports indicated that the concentration of fine dust in Korea has been on a declining trend since 2007, but only slightly increased in 2013. In Kim’s study, as reported in our research, the news of fine dust-related media rapidly increased from the year 2013, and the perceived risk that did not actually exist tends to be misconstrued as a risk issue due to the explosive increase in media coverage. In addition, despite the fact that these studies are media reports related to fine dusts, there has been an increase in the number of reports for the purpose of promoting and selling specific products. The problem with these reports is that they can provide distorted information to achieve commercial purposes rather than present solutions to effectively address such risk situations as fine dust.

Fine dust is very small in size and enters the body through the breath of man, accumulates, and causes various health problems. Many studies have reported that exposure to micro dust promotes mortality-related illnesses, such as changes in blood pressure, respiratory diseases, cardiovascular diseases, and stroke. Other studies have reported that, as well as health problems causing damage to the industry, such as primary industries, transport, and manufacturing. Due to these negative effects, the public interest and concern about fine dust increases with the passage of time. To do this, accurate research and policy should be established so that the public can understand and judge correctly, without explaining the causes of the risk factors, not only in the media but...
also in government and academia. Min proposed the countermeasures of each institution for effective resolution of fine dust. First, the government should establish a solution through an integrated approach involving ministries. Second, the communication between the ministries and the public should be more open than the existing methods and it is necessary to improve the current administrative procedures and customs which may be obstacles to the identification of risk factors. Kim et al. said that in South Korea, where the Internet and social networking service is very well-developed, the public perception is formed almost by the frequency of media reports regardless of the actual concentration and frequency of particulate matter and its harmful effects on health. In addition, some studies show that the public overexposed to fragmented media reporting environmental stress factors such as particulate matter negatively aware of risk related health by emphasizing the role of communication for the public.

Third, it is suggested that academia should have a consciousness to solve the problem of air quality pollution, and should be able to converge various opinions based on an open research climate. Finally, the media should be able to fulfill the positive role of the media through fair reporting, devoid of the indulgence of irritating themes, and to be able to wait for the “right time” of academics and government. The government’s interpretation and reflection of the policy should not lose the sense of the cold report.

The limitations of our study are as follows. First, we did not control for bias from variables that could influence the correlation between micro dust media footprints and walking time reduction. The data were analyzed by two approaches, which were gradually based on the information provided by public authorities to determine their relevance; it seems a missed approach and the nature of the difficulty of interesting items of secondary materials. In addition, the reliability and validity of the analysis depends on the ability of the researcher to select the necessary information in the secondary data. Second, we could not determine the actual effects of decreased walking time on human health and health effects in detail. This is also as a result of the limitation from the use of secondary data on the Internet which seems to be a missing item in this study. Especially, the number of media related to fine dust affected the walking time of Korean people rather than the actual concentration of fine dust. We conclude that the increase in indiscriminate media reports without identifying various internal and external factors of risk factors, such as explosive increase in fine dust concentration, could be the cause. In addition, by analyzing various variables, such as the number of health behavior practice sites (number of parks, number of sport sites), awareness of social safety, and afraid of night activities, related to changes in walking time and health status during this period, it was concluded that a decrease in physical activity could have a negative impact on health status. Therefore, these phenomena are not not temporary or rapid, as our results. So, this study hope to call attention of all walks of life for the citizens of the Republic of Korea to change health-related behaviors.

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References
1. Republic of Korea: Ministry of Environment. Enforcement Rule of the Special Act on the Reduction and Management of Fine Dust. Republic of Korea. Ministry of Environment. (2019). https://www.law.go.kr/iLawInfoDo?isSeq=20784960YD=2019021549006
2. Hwang, I.-C. Correct Direction of Fine Dust Solution—Need to cope with fine dust and set new direction. Republic of Korea. Korea Pet. Assoc. J. 307, 20–23 (2018).
3. Ju, Y.-K. & You, M.-S. The outrage effect of personal stake, dread, and moral nature on fine dust risk perception moderated by media use. Health Commun., 1–11 (2020).
4. Kim, Y.-H. Risk communication. Republic of Korea. Communication Books. 1–270 (2014) ISBN: 9791130401089
5. Republic of Korea: Ministry of Environment. A Study on the Production Process of Urban Area PM2.5. Republic of Korea. National Institute of Environment Research. (2010). https://www.nl.go.kr/app/nl/search/common/download.jsp?file_id=FILE-00008149029
6. Republic of Korea: Ministry of Environment. Establish detailed implementation plan for special measures for fine dust management. Republic of Korea. Republic of Korea Policy Briefing. (2016). https://www.korea.kr/news/policyBriefingView.do;SESSIONID_KOREA=pnBp2cHJZevx2y1XLstQlWThwXb7H7pF2FJhcF2D6d5S0D7=7599907658309919994?newsId=156140002
7. Kim, C.-H. et al. On the recent air pollution levels observed in the regional air monitoring network—High air pollution concentration episodes and their meteorological characteristics in 2002. J. Korean Soc. Atmos. Environ. 20, 215–224 (2004).
8. Jin, H.-A. et al. The estimation of PM 2.5 emissions and their contribution analysis by source categories in Korea. J. Korean Soc. Atmospheric Environ. 28, 211–221 (2012).
9. Park, S. & Shin, H. Analysis of the factors influencing PM2.5 in Korea: Focusing on seasonal factors. J. Environ. Policy Adm 25, 227–248 (2017).
10. Sin Y. Jumbled dust forecast… had to Direct measured the concentration' Republic of Korea Community Broadcasting Station. Republic of Korea. JTBC. (2016). https://news.jtbc.joins.com/article/article.aspx?news_id=NB112121418
11. Lee, S.-H. et al. Analysis of PM 2.5 case study burden at Chungju City. J. Korean Soc. Atmos. Environ. 28, 595–605 (2012).
12. Kim, J.-H., Choi, D.-R., Koo, Y.-S., Lee, J. & Park, H.-J. Analysis of domestic and foreign contributions using DDM in CMAQ during particulate matter episode period of February 2014 in Seoul. J. Korean Soc. Atmos. Environ. 32, 82–99 (2016).
13. Yao, L. et al. Sources apportionment of PM2.5 in a background site in the North China Plain. Sci. Total Environ. 541, 590–598 (2016).
14. Choi, C.-I. & Kim, C.-M. Path dependency and social amplification of risk in particulate matter air pollution management and its implications. J. Korean Regional Dev. Assoc. 28, 89–107 (2016).
Kim, Y.-H. Risk, Crisis and Communication: in the modern society in terms of communication and discusses practical countermeasures (Korean Edition). Seoul. Ewha Womans University Press. (2008). ISBN: 8973008099, 9788973008097

Republic of Korea-Centers for Disease Control & Prevention. Republic of Korea: 2008–2017.

Republic of Korea-Ministry of Environment, Environmental Statistics Yearbook 2017: Concentration Level of Particulate Matter (PM10) in Major Cities. Republic of Korea. Republic of Korea-Ministry of Environment, Environment and Nutrition Examination Survey. (2018). https://knhanes.cdc.gov/knhanes/main.do

Republic of Korea-Ministry of Statistics. Korea City Statistics. Republic of Korea.

Republic of Korea-Ministry of Statistics. Social Survey 2008–2018: Awareness of social safety & Afraid for Night Walking. Republic of Korea.

Republic of Korea-Korea Press Foundation-News Big Data & Analysis System: The Big Kinds. Mass Media Exposure Data. Republic of Korea.

Lee, I.-M. & Buchner, D. M. The importance of walking to public health.

Park, J.-Y. & Kim, N.-H. The relationship between physical activity and insulin resistance in the middle-aged adults.

Lee, E. S. Exercise motivations of the participated in screen golf -involvement, fun, and presence factors.

Kim, M.-S., Kim, S.-H. & Lee, S.-H. Effects of walking exercise for wellness convergence in the digital aged-based on physical activity. J. Digit. Conv. 13, 365–374 (2015).

Park, J.-Y. & Kim, N.-H. The relationship between physical activity and insulin resistance in the middle-aged adults. J. Korean Biol. Nurs. Sci. 13, 245–252 (2011).

Kim, H., Han, Y., Kim, B. & Ryu, S. Relevance of vitamin D and dyslipidemia among Korean adults-using data from the Sixth Korea National Health and Nutrition Examination Survey, 2013–2014. J. Korean Acad. Ind. Coop. Soc. 18, 647–656 (2017).

Kim, M.-S., Kim, S.-H. & Lee, S.-H. Effects of walking exercise for wellness convergence in the digital aged-based on physical activity. J. Digit. Conv. 13, 365–374 (2015).

Kim, M.-S., Kim, S.-H. & Lee, S.-H. The correlations of walking exercise-program induced abdominal visceral fat loss with metabolic syndrome risk factors. J. Digit. Conv. 14, 589–596 (2016).

Kim, H. Effects of Social support based walking program on community. J. Digit. Conv. 12, 357–364 (2014).

Park, D. & Jang, E. Convergence factors related to glycemic control in workers with diabetes mellitus: using the Korean National Health and Nutrition Examination Survey, 2009–2013. J. Korean Soc. Conv. 6, 95–103 (2015).

López-Guimerá, G., Levine, M. P., Sánchez-carracedo, D. & Fauquet, J. Influence of mass media on body image and eating disordered attitudes and behaviors in females: a review of effects and processes. Media Psychol. 13, 387–416 (2010).

Wu, X. & Li, X. Effects of media mass exposure and social network site involvement on risk perception of and precautionary behavior toward the haze issue in China. Int. J. Commun. 11, 23 (2017).

You, M. & Ju, Y. Interaction of individual framing and political orientation in guiding climate change risk perception. J. Risk Res. 22(7), 865–877 (2019).

Choi, D. H., Yoo, W., Koh, G. Y. & Park, K. The impact of social media on risk perceptions during the MERS outbreak in South Korea. Comput. Hum. Behav. 72, 422–431 (2017).

Witz, C. D. et al. Rethinking social amplification of risk: Social media and Zika in three languages. Risk Anal. 38(12), 2599–2624 (2018).

Republic of Korea-Ministry of Government Legislation. Available online: www.moleg.go.kr. Accessed on 24 Feb 2020

Choi, C. G. & Kim, C. M. Path dependency and social amplification of risk in participative matter air pollution management and its implications. J. Korean Reg. Dev. Assoc. 28, 89–107 (2016).

Kim, J.-H., Yoo, S.-H. & Sim, S.-Y. Unveiling the meaning of walking for health promotion: the perspectives of urban walkers. Korean J. Health Educ. Promot. 28, 63–77 (2011).

Monness, E. & Sjölie, A. An alternative design for small-scale school health experiments: does daily walking produce benefits in physical performance of school children?. Child Care Health Dev. 35, 858–867 (2009).

Pucher, J., Buehler, R., Bassett, D. R. & Dannenberg, A. L. Walking and cycling to health: a comparative analysis of city, state, and international data. Am. J. Public Health 100, 1986–1992 (2010).

Craddock, A. L. et al. Factors associated with federal transportation funding for local pedestrian and bicycle programming and facilities. J. Public Health Policy 30, 538–572 (2009).

Wallmann-Sperlich, B., Froboese, I. & Schantz, P. Physical activity and the perceived neighbourhood environment—looking at the association the other way around. Int. J. Environ. Res. Public Health 11, 8093–8111 (2014).

Águedóttir, T., L. Corman, H., Noonan, K., Olafsdottir, P. & Reichman, N. E. Was the economic crisis of 2008 good for Icelanders? Impact on health behaviors. Econ. Hum. Biol. 13, 1–19 (2014).

Cortés-Franck, I. & González, B. L. V. The economic-financial crisis and health in Spain. Evidence and viewpoints. SESPAS report 2014. Gac. Sanit. 28, 1–6 (2014).

Filippidis, F. T. et al. Trends in cardiovascular risk factors before and during the financial crisis: the impact of social disparities. Eur. J. Public Health 24(6), 974–979 (2014).

Lee, E. S. Exercise motivations of the participated in screen golf -involvement, fun, and presence factors. Korean Soc. Leisure Recreat. 33(2), 73–83 (2009).

Shin young Jeon. The global economic crisis and blind spots of health security. Korean Assoc. Soc. Policy 17(1), 95–127 (2010).

Kim, M.-G. & Suh, S.-R. The ecological factors affecting walking in Korean adult workers. J. Korean Acad. Ind. Coop. Soc. 18, 68–78 (2017).

Lee, J.-H. Fine dust. Worse by China?. Republic of Korea. Korea Broadcasting Journalist Association. (2018). https://reportplus.kr/?p=22788

Kim, Y.-W. et al. A study of the public perception an opinion formation on particulate matter risk—focusing on the moderating effects of the perceptions toward promotional news and involvement. Korean J. Commun. Inf. 21(1), 53–117 (2016).

Kim, B., Yoon, E. J., Kim, S. & Lee, D. K. The effects of risk perceptions related to particulate matter on outdoor activity satisfaction in South Korea. Int. J. Environ. Res. Public Health 17(5), 1613 (2020).

Bramš, M., Řežáčová, P. & Domasová, M. The effect of outdoor air and indoor human activity on mass concentrations of PM10, PM2.5, and PM1 in a classroom. Environ. Res. 99(2), 143–149 (2005).

Eom, Y. S., Kim, J. O. & Ahn, S. E. Measuring willingness to pay for PM 10 risk reductions: evidence from averting expenditures for anti-PM 10 masks and air purifiers. Environ. Resource Econ. Rev. 28(3), 355–383 (2019).
56. Kim, B. & Lee, D. K. A study on perception change in bicycle users’ outdoor activity by particulate matter: based on the social network analysis. *J. Environ. Impact Assess.* 29(5), 440–456 (2019).
57. Kim, Y. U., Lee, H. S., Lee, H. J. & Jang, Y. J. A study on the recognition and opinion formation of audience reports. *Korean Soc. J. Commun. Stud.* 5, 20–21 (2019).
58. Kim, S. J. et al. Multi-temporal analysis of forest fire probability using socio-economic and environmental variables. *Remote Sens.* 11(1), 86 (2019).
59. Park, S. Y. Expansion of coal power plant, the main culprit of fine dust, in China’s Shandong Province next to Korea. Republic of Korea. *JTBC.* (2018). [https://news.jtbc.joins.com/article/article.aspx?news_id=NIB1621437](https://news.jtbc.joins.com/article/article.aspx?news_id=NIB1621437)
60. Atwater, T., Salwen, M. B. & Anderson, R. B. Media agenda-setting with environmental issues. *J. Q.* 62, 393–397 (1985).
61. Xing, Y.-F., Xu, Y.-H., Shi, M.-H. & Lian, Y.-X. The impact of PM2.5 on the human respiratory system. *J. Thorac. Dis.* 8, E69 (2016).
62. Auchincloss, A. H. et al. Associations between recent exposure to ambient fine particulate matter and blood pressure in the Multi-Ethnic Study of Atherosclerosis (MESA). *Environ. Health Perspect.* 116, 486–491 (2008).
63. Brook, R. D. et al. Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association. *Circulation* 121, 2331–2378 (2010).
64. Rice, M. B. et al. Short-term exposure to air pollution and lung function in the Framingham Heart Study. *Am. J. Respir. Crit. Care Med.* 188, 1351–1357 (2013).
65. Choi, E.-K., Yu, S.-Y., Kim, S.-W. & Yun, S.-M. Study on the economic losses in the industrial sector in case of a Mt. Baekdu eruption scenario. *Int. Area Stud. Rev.* 18, 145–168 (2014).
66. Min, K.-E. Breathing How are you?—Misunderstanding, truth and approach to fine dust. *J. Environ. Stud.* 58, 14–23 (2016).
67. Kim, Y. W., Lee, H. S., Jang, Y. J. & Lee, H. J. How does media construct particulate matter risks? A news frame and source analysis on particulate matter risks. *Korean J. Journal. Commun. Stud.* 59(2), 121–154 (2015).
68. Park, J. Y. & Kim, N. J. The effect of the media's report of particulate matter on the behavioral intentions in terms of domestic tourism in Korea: focusing on the risk perception of particulate matter. *J. Tour. Sci.* 43, 49–69 (2019).
69. Orru, K., Orru, H., Maasikmets, M., Hendrikson, R. & Ainsaar, M. Well-being and environmental quality: does pollution affect life satisfaction?. *Qual. Life Res.* 25(3), 699–705 (2016).
70. Terris, D. D., Litaker, D. G. & Koroukian, S. M. Health state information derived from secondary databases is affected by multiple sources of bias. *J. Clin. Epidemiol.* 60, 734–741 (2007).

**Competing interests**
The authors declare no competing interests.

**Additional information**

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