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Effect of High Temperature on Walking among Residents of Rural and Urban Communities

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Purpose: This study aimed to establish the association between high temperature and walking among residents of rural and urban areas.

Materials and Methods: This cross-sectional study used data from the Korea Meteorological Administration and the 2018 Community Health Survey to confirm the association between temperature and walking practice. The dependent variable was walking practice. Walking practice was considered if the participants walked for more than 30 minutes a day or more than 5 days a week. The independent variable was the daily maximum temperature (°C) for the preceding 7 days, calculated from the survey date of each participant. A multilevel analysis was conducted to simultaneously consider the individual- and neighborhood-level variables that could affect determining the association between daily maximum temperatures and walking practice.

Results: When the daily maximum temperature increased by 1°C, the odds ratio of walking practice decreased to 0.95 (95% confidence interval 0.94–0.97) in rural areas. In contrast, it decreased to 0.98 (95% confidence interval 0.97–1.00) in urban areas, considering both individual- and neighborhood-level factors. Individual- and neighborhood-level determinants of walking practice in rural areas, including educational attainment, marital status, driving a car, subjective health, depression, and meeting neighbors and friends, were confirmed.

Conclusion: This study confirmed that increased temperature led to more decrease in physical activity levels in rural areas than in urban areas. Physical and environmental approaches to avoid heat are needed to maintain and promote physical activity, since temperatures can reduce physical activity during the hot summer months.

Key Words: Hot temperature, heatwave, walking, exercise, rural population, rural health

INTRODUCTION

Walking is one of the physical activities that people of all ages can practice due to its ease and safety.[1] Walking for more than 150 minutes a week has positive health effects, including reducing cardiovascular disease risk factors such as hypertension, diabetes, obesity,[2] and all-cause mortality.[3] Many previous studies have used socio-ecological models to identify walking practice determinants. This is not limited to personal factors but also considers various levels of factors that may affect one's behavior.[4] Several walking practice determinants have been identified, including demographic (sex, age, education, income, occupation),[5,6] physical (disability, pain, overweight),[7,8] psychological (social support, fear, self-efficiency),[9,10] built environmental (walkability, accessibility to services, parks, sports facilities, safety),[11,12] and natural environmental factors (air pollution, air temperature, rainfall, sunlight).[8,13]

Weather factors, such as sunlight, temperature, and precipitation, can prevent outdoor walking.[14,15] However, there is a lack of research that combines weather and seasonal effects with other walking practice determinants. Most studies considering

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meteorological factors have identified warm weather's positive effect on physical activity during cold winter climates.[16,17] Very few studies have identified the effects of high temperatures on physical activity in summer. In addition, few studies have been conducted on specific groups, especially female, the elderly, children, chronically ill people, people with disabilities, rural residents, and socially isolated or underdeveloped people, who are vulnerable to high temperatures and heatwaves. This study aimed to establish the association between high temperature and walking among residents of rural and urban areas.

MATERIALS AND METHODS

Study design and setting

This cross-sectional study used data from the Korea Meteorological Administration and the 2018 Community Health Survey to confirm the association between temperature and walking practice. The 2018 Community Health Survey was conducted from August 16, 2018 to October 31, 2018.

Participants

The study subjects were Koreans aged ≥19 years, living in 18 cities and counties in Gyeongsangnam-do, who participated in the 2018 Community Health Survey. Of the 17947 respondents surveyed, 17750 were finally selected after excluding 197 with missing values among the analytic variables.

Variables

Outcomes

The dependent variable was walking practice. The Community Health Survey examined how many days one has walked for at least 10 minutes concurrently in the past week, including commuting to and from school, traveling, and exercising, and how long one usually walks a day in the past week. According to the World Health Organization recommendations on physical activity for sound health,[18] walking practice was considered when the participants practiced walking for more than 30 minutes a day or more than 5 days a week. Walking practice was used as a dichotomous variable: "walking practice (walking practice: yes)" and "walking not performed (walking practice: no)."

Predictors

The independent variable was the daily maximum temperature (°C). The raw data from the university conducting the survey provided the exact date of the survey and the residential areas at the town level (Eup/Meyon/Dong) of each participant. The Korea Meteorological Administration Weather Data Service provided hourly air temperatures in the towns. After constructing the daily maximum temperature data as hourly maximum, the average value of the regional maximum temperature data for the preceding 7 days was calculated from each participant's survey date.

Covariates

Individual-level variables included sex (male, female), age (19–29, 30–49, 50–64, and ≥65 years), educational attainment (≥12 years, <12 years, none), employment status (employed, unemployed), marital status (married, divorced, bereaved, separated, or single), driving a car (no, yes), subjective health status (good or poor), depression (no, yes), meeting neighbors (≥once a month, <once a month), and meeting friends (≥once a month, <once a month). Neighborhood-level variables at the regional level included the traffic culture index and the proportion of road pavement in percentage. The traffic culture index is an index of the behavior patterns of drivers and pedestrians using traffic, which is calculated by the Ministry of Land, Infrastructure and Transport from the Traffic Culture Survey. It is a number quantified by 100 points by investigating and analyzing three items (driving behavior, walking behavior, and traffic safety) and 18 evaluation indicators. The larger the traffic culture index value, the better the transportation culture. The unit of the neighborhood-level variables was 18 cities and counties in Gyeongsangnam-do.

Statistical analysis

According to the administrative area town level, we defined the Eup or Dong area as an urban area and the Myeon area as a rural area in order to represent the urban and rural areas of Gyeongsangnam-do. Differences in daily maximum temperature and walking practice in urban and rural areas were identified using the chi-squared and the Wilcoxon rank-sum tests. We also performed the Pearson's correlation analysis to determine the linear relationship between the daily maximum temperature and the proportion of walking practice in rural and urban areas. The scatter plot showed the relationship between mean daily maximum temperature and proportion of walking practice based on the survey data with a linear regression line and a trend line in rural and urban regions. The trend line was indicated by the locally weighted scatterplot smoothing (LOWESS) curve using the R software. A multilevel analysis was conducted to simultaneously consider the individual- and neighborhood-level variables that could affect determining the association between daily maximum temperatures and walking practice. Using the logit linkage function, we applied a multilevel logistic regression model that can express binomial distribution as a linear relationship. It was a random intercept model, which can estimate the random effects of the regions' intercepts and the fixed effects of the controlled independent variable. In the calculated regression formula, it was assumed that the intercept was different for each region and that the slope was the same. In this study, we constructed multilevel analysis models using the null and the three research models as follows:

- Null model: does not contain both individual and neighborhood-level variables
- Research model 1: with only daily maximum temperature variable
- Research model 2: with daily maximum temperature+individual-level variables
- Research model 3: with all daily maximum temperatures+individual-level variables+neighborhood-level variables.

Variations between regions were evaluated to confirm whether the model was suitable for multilevel analyses. A multilevel analysis should be performed if there is variation between regions ($\tau 00 \neq 0$). To confirm this variation between regions, we measured the intraclass correlation, the ratio of regional level variance among the total variance. The likelihood ratio test was conducted to verify the model's suitability. We calculated the -2 log-likelihood (-2LL); the smaller the value, the better the model's fit. Each model's explanatory power was expressed as the ratio of the variance of each research model explained by the addition of each research model's variables in the null model variance (percentage change in variation, PCV). Statistical significance was set at <0.05, and R3.6.3 (R Foundation for Statistical Computing, Vienna, Austria) was used for analysis. The glmer function of the R software lme4 package was used for multilevel analysis.

RESULTS

Baseline characteristics of study participants

Of the 17750 study participants, 7839 (44.2%) lived in rural areas (Myeon areas) and 9911 (55.8%) lived in urban areas (Eup and Dong areas). The participants' individual and neighborhood characteristics in rural and urban areas are shown in Table 1. The proportion of female, people aged ≥65 years, uneducated and unemployed people, divorced, bereaved, or separated people, people who did not drive cars, people with good subjective health, people with depression, people meeting their neighbors more than once a month, and people meeting their friends less than once a month in rural areas were higher than those in urban areas. The median traffic culture index was 5.62 points lower in rural areas. In addition, the median proportion of road pavement was 8.70% lower in rural areas than in urban areas.

Daily maximum temperature and walking practice

The mean daily maximum temperatures in rural and urban areas were 27.18±3.48°C and 25.52±3.33°C, respectively, and that in rural areas was 1.66°C higher compared to urban areas (Table 2). In rural areas, 35.08% of the study participants walked for more than 30 minutes a day or more than 5 days a week over the past week from the date of the survey; 36.41% of the subjects performed the walking practice in urban areas (Table 3). However, there was no statistically significant difference between the rural and urban areas in walking practice. The relationship between the daily maximum temperature and the proportion of walking practice was negative in rural areas (r=-0.667, p<0.001). In urban areas, the Pearson's correlation co-

Table 1. Characteristics of Individual- and Neighborhood-Level Variables in Rural and Urban Areas

Characteristics	Total (n=17750)	Rural areas (n=7839)	Urban areas (n=9911)	*p* value
Individual-level				
Sex				0.001
Male	7750 (43.66)	3316 (42.30)	4434 (44.74)	
Female	10000 (56.34)	4523 (57.70)	5477 (55.26)	
Age (yr)				<0.001
19–29	1267 (7.14)	295 (3.76)	972 (9.81)	
30–49	4678 (26.35)	1224 (15.61)	3454 (34.85)	
50–64	5259 (29.63)	2234 (28.50)	3025 (30.52)	
≥65	6546 (36.88)	4086 (52.12)	2460 (24.82)	
Educational attainment (yr)				<0.001
≥12	4215 (23.75)	1114 (14.21)	3101 (31.29)	
<12	11856 (66.79)	5433 (69.31)	6423 (64.81)	
0	1679 (9.46)	1292 (16.48)	387 (3.90)	
Employment				<0.001
Employed	10680 (60.17)	4472 (57.05)	6208 (62.64)	
Unemployed	7070 (39.83)	3367 (42.95)	3703 (37.36)	
Marital status				<0.001
Married	12020 (67.72)	5114 (62.24)	6906 (69.68)	
Divorced, bereaved, or separated	3774 (21.26)	2143 (27.34)	1631 (16.46)	
Single	1956 (11.02)	582 (7.42)	1374 (13.86)	
Driving a car				<0.001
No	8439 (47.54)	4432 (56.54)	4007 (40.43)	
Yes	9311 (52.46)	3407 (43.46)	5904 (59.57)	
Subjective health				<0.001
Good	5389 (30.36)	2068 (26.38)	3321 (33.51)	
Poor	12361 (69.64)	5771 (43.46)	6590 (66.49)	
Depression				<0.001
No	17107 (96.38)	7480 (95.42)	9627 (97.13)	
Yes	643 (3.62)	359 (4.58)	284 (2.87)	
Meeting neighbors				<0.001
≥Once a month	13878 (78.19)	7106 (90.65)	6772 (68.33)	
<Once a month	3872 (21.81)	733 (9.35)	3139 (31.67)	
Meeting friends				<0.001
≥Once a month	14166 (79.81)	5663 (72.24)	8503 (85.79)	
<Once a month	3584 (20.19)	2176 (27.76)	1408 (14.21)	
Neighborhood level				
Traffic culture index (point)	73.25 (68.51–78.34)	70.83 (68.15–74.24)	76.45 (70.83–78.34)	<0.001
Proportion of road pavement (%)	95.70 (83.50–99.20)	87.00 (77.80–97.90)	95.70 (89.30–99.20)	<0.001

Values are presented as n (%) or medians (interquartile ranges). *P*-values were determined using the chi-squared test and the Wilcoxon rank-sum test.

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efficient (r) was 0.062, but it was not statistically significant (p= 0.599) (Fig. 1).

Multilevel analysis for walking practice in rural and urban areas

Table 4 shows the multilevel analysis results, which identified the effects of daily maximum temperature on walking practices in rural areas. In research model 1, when the daily maximum temperature increased by 1°C, the walking practice odd ratio (OR) decreased to 0.95. Third, in research model 2, which included individual-level factors, when the daily maximum temperature increased by 1°C, the walking practice OR decreased to 0.95, considering the individual-level factors. In addition, this model identified the walking practice individual-level determinants. The research model 3 revealed the association between daily maximum temperature and walking practice after considering individual- and regional-level variables. When the daily maximum temperature increased by 1°C, the walking practice OR decreased to 0.95, considering both individual- and neighborhood-level factors. The PCV of research model 3 was 17.50%, which increased the model's explanatory power by 1.93% compared to research model 1 and by 4.55% compared to research model 2. The -2LL of research model 3 was 9669.01, which improved the model fit compared to the null and research models 1 and 2.

Table 5 shows the multilevel analysis results, which identified the effects of daily maximum temperature on walking practices in urban areas. In research model 3, which included individual- and neighborhood-level factors, when the daily maximum temperature increased by 1°C, the walking practice OR decreased to 0.98. The effect size was smaller than that in rural areas.

Table 2. Daily Maximum Temperature in Rural and Urban Areas

Daily maximum temperature	Total	Rural areas	Urban areas	p value
Mean±standard deviation	26.25±3.50	27.18±3.48	25.52±3.33	<0.001
Minimum	17.71	17.71	18.14	
1Q	23.77	24.74	23.41	
Median	25.96	26.89	25.39	
3Q	28.87	29.93	27.57	
Maximum	34.40	34.40	34.13	

P-value was determined using the Wilcoxon rank-sum test.

Table 3. Walking Practice in Rural and Urban Areas

Walking practice	Total	Rural areas	Urban areas	p value
No	11391 (64.17)	5089 (64.92)	6302 (63.59)	0.068
Yes*	6359 (35.83)	2750 (35.08)	3609 (36.41)	

*Defined as walking more than 30 minutes a day and more than 5 days a week over the past week from the date of the survey. P-value was determined using the chi-squared test.

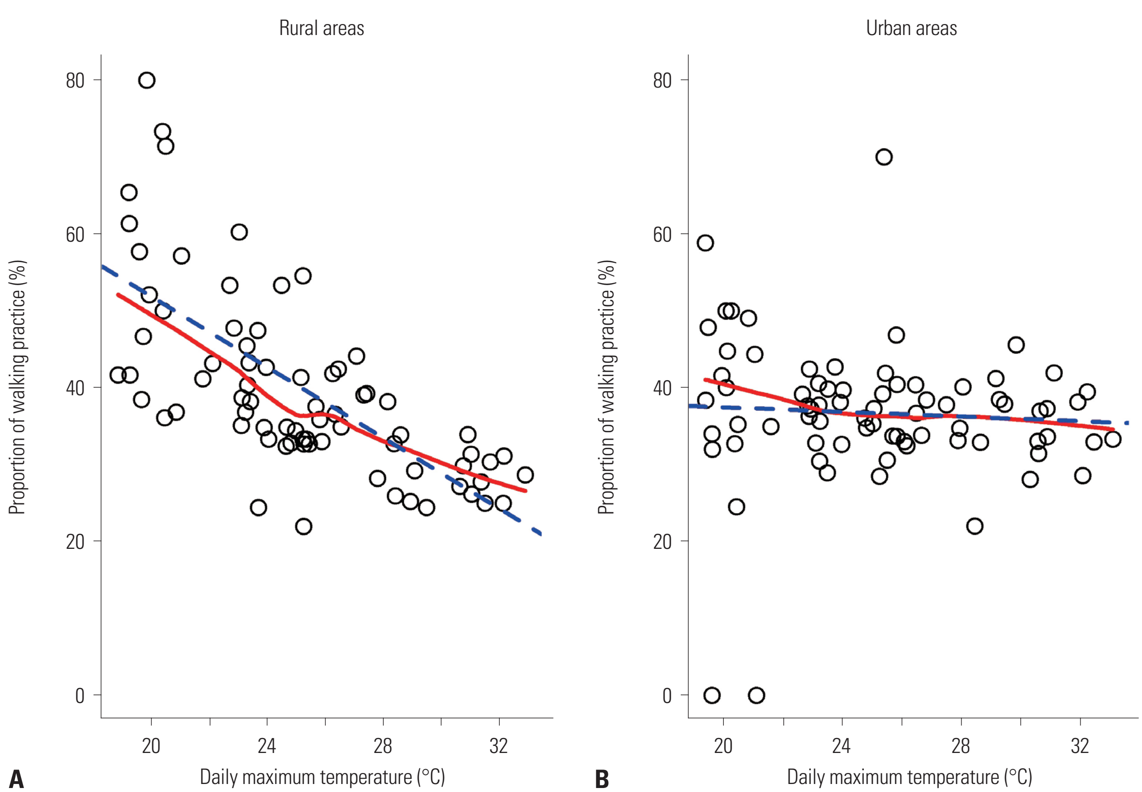

Fig. 1. Relationship between mean daily maximum temperature and proportion of walking practice based on the survey data with a linear regression line (dashed blue line) and a trend line (solid red line) in rural areas (A) and urban areas (B).

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Table 4. Multilevel Logistic Regression Model: OR for Walking Practice by Individual- and Neighborhood-Level Factors in Rural Areas

Factors	Null model			Research model 1			Research model 2			Research model 3		
	OR	95% CI	*p* value	OR	95% CI	*p* value	OR	95% CI	*p* value	OR	95% CI	*p* value
Fixed effects												
Intercept	0.55	0.44–0.68	<0.001*	2.13	1.36–3.32	0.001*	2.89	1.61–5.20	<0.001*	0.64	0.02–23.73	0.811
Daily maximum temperature (°C)				0.95	0.94–0.97	<0.001*	0.95	0.94–0.97	<0.001*	0.95	0.94–0.97	<0.001*
Individual-level												
Sex: female/male							0.94	0.83–1.05	0.254	0.94	0.83–1.05	0.253
Age (years): 30–49/19–29							1.04	0.74–1.45	0.832	1.04	0.74–1.45	0.829
Age (years): 50–64/19–29							1.35	0.95–1.92	0.095	1.35	0.95–1.92	0.093
Age (years): ≥65/19–29							1.33	0.93–1.91	0.122	1.34	0.93–1.92	0.117
Educational attainment (years): <12/≥12							0.93	0.79–1.09	0.371	0.93	0.79–1.09	0.372
Educational attainment (years): 0/≥12							0.70	0.56–0.88	0.002*	0.71	0.56–0.88	0.002*
Employment: unemployed/employed							0.98	0.87–1.09	0.676	0.98	0.87–1.09	0.664
Marital status: divorced, bereaved, separated/married							0.78	0.69–0.89	<0.001*	0.78	0.69–0.89	<0.001*
Marital status: single/married							0.93	0.72–1.20	0.588	0.93	0.73–1.20	0.596
Driving a car: yes/no							0.80	0.70–0.92	0.001*	0.80	0.70–0.93	0.001*
Subjective health: poor/good							0.76	0.68–0.85	<0.001*	0.76	0.68–0.85	<0.001*
Depression: yes/no							0.62	0.48–0.80	<0.001*	0.62	0.48–0.82	<0.001*
Meeting neighbors: <once a month/≥once a month							0.82	0.68–0.98	0.029*	0.81	0.68–0.98	0.026*
Meeting friends: <once a month/≥once a month							0.79	0.70–0.89	<0.001*	0.79	0.70–0.89	<0.001*
Neighborhood level												
Traffic culture index (point)										1.01	0.97–1.05	0.628
Proportion of road pavement (%)										1.01	0.99–1.03	0.349
Random effects												
Between region variance (SD)	0.20 (0.45)			0.17 (0.41)			0.18 (0.42)			0.17 (0.41)		
Adjusted ICC	0.06			0.05			0.05			0.05		
-2 log-likelihood (deviance)	9852.96			9808.33			9669.96			9669.01		
PCV (%)				15.57			12.95			17.50		

OR, odds ratio; CI, confidence interval; SD, standard deviation; ICC, intraclass correlation; PCV, percentage change in variation.
Research model 1 included daily maximum temperature only. Research model 2 included daily maximum temperature and individual-level factors. Research model 3 included daily maximum temperature, individual, and neighborhood-level factors.
*$p<0.05$.

DISCUSSION

This study identified the association between high temperature and walking practices in rural adults using weather data from the Korea Meteorological Agency and the 2018 Community Health Survey data. After considering the individual and neighborhood determinants affecting walking practice, increasing daily maximum temperatures between August and October reduced the walking practice OR, especially in rural areas. Various previous studies have also confirmed the negative relationship between high temperatures and physical activity. The number of steps increased until the daily maximum temperature reached 29°C; however, in an urban resident study in the Southern United States, it was found that if the daily maximum temperature was higher than 29°C, the step counts decreased.[19] In a study of older adults in Canadian communities, the physical activity level was relatively constant until the average daily temperature in summer reached 30°C. When the average daily temperature exceeded 30°C, physical activity decreased rapidly.[20] A Japanese community study also revealed that the mean daily temperature increased from -2°C to 17°C but decreased in the 17°C to 29°C temperature range.[21]

The results of this study confirmed the determinants that affect rural residents' walking practices. Individual-level determinants were educational attainment, driving a car, subjective health, depression, marital status, and the frequency of meeting neighbors and friends. Uneducated people's walking practice OR of 0.71 was relatively lower than that of those who had graduated from high school or higher. People with certificates or higher education got more exercise.[22] Female with higher education had more fun when walking for leisure time activities.[23] Compared to non-motorists, motorists performed

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Table 5. Multilevel Logistic Regression Model: OR for Walking Practice by Individual- and Neighborhood-Level Factors in Urban Areas

Factors	Null model			Research model 1			Research model 2			Research model 3		
	OR	95% CI	*p* value	OR	95% CI	*p* value	OR	95% CI	*p* value	OR	95% CI	*p* value
Fixed effects												
Intercept	0.52	0.46–0.60	<0.001*	0.73	0.51–1.04	0.079	1.51	0.98–2.33	0.063	0.09	0.01–0.90	0.039*
Daily maximum temperature (°C)				0.99	0.97–1.00	0.046*	0.98	0.97–1.00	0.018*	0.98	0.97–1.00	0.016*
Individual-level												
Sex: female/male							0.78	0.71–0.86	<0.001*	0.78	0.71–0.86	<0.001*
Age (years): 30–49/19–29							0.92	0.75–1.13	0.428	0.92	0.75–1.13	0.436
Age (years): 50–64/19–29							1.18	0.95–1.47	0.136	1.18	0.95–1.47	0.134
Age (years): ≥65/19–29							1.12	0.89–1.41	0.335	1.12	0.89–1.42	0.321
Educational attainment (years): <12/≥12							1.04	0.93–1.15	0.515	1.04	0.93–1.15	0.054
Educational attainment (years): 0/≥12							0.58	0.44–0.76	<0.001*	0.58	0.45–0.76	<0.001*
Employment: unemployed/employed							1.18	1.07–1.30	0.001*	1.17	1.06–1.30	0.002*
Marital status: divorced, bereaved, separated/married							0.89	0.78–1.00	0.056	0.86	0.78–1.00	0.057
Marital status: single/married							1.05	0.88–1.25	0.596	1.05	0.88–1.26	0.587
Driving a car: yes/no							0.59	0.53–0.65	<0.001*	0.59	0.53–0.66	<0.001*
Subjective health: poor/good							0.73	0.66–0.80	<0.001*	0.73	0.66–0.80	<0.001*
Depression: yes/no							0.86	0.66–1.12	0.268	0.86	0.67–1.12	0.271
Meeting neighbors: <once a month/≥once a month							0.82	0.74–0.90	<0.001*	0.81	0.74–0.90	<0.001*
Meeting friends: <once a month/≥once a month							0.72	0.63–0.82	<0.001*	0.72	0.63–0.82	<0.001*
Neighborhood level												
Traffic culture index (point)										1.02	1.00–1.05	0.092
Proportion of road pavement (%)										1.01	1.00–1.03	0.018*
Random effects												
Between region variance (SD)		0.08 (0.29)			0.08 (0.29)			0.09 (0.30)			0.06 (0.24)	
Adjusted ICC		0.02			0.02			0.03			0.02	
-2 log-likelihood (deviance)		12901.75			12897.75			12600.40			12594.30	
PCV (%)					-1.35			-9.09			27.27	

OR, odds ratio; CI, confidence interval; SD, standard deviation; ICC, intraclass correlation; PCV, percentage change in variation.
Research model 1 included daily maximum temperature only. Research model 2 included daily maximum temperature and individual-level factors. Research model 3 included daily maximum temperature, individual, and neighborhood-level factors.
*$p<0.05$.

lesser walking practice. Previous studies have also reported that individual car ownership reduced the number of traffic-related walking and bicycling.[24] The walking practice rate was high for more than 30 minutes a day in areas where the number of registered cars per person was low.[25] Regarding health conditions, walking practice decreased when the subjective health level was poor or when symptoms of depression were present. In a previous study, adults with good subjective health had high exercise and overall physical activity levels.[26] A systematic review identified an association between depression and physical activity. Depression sustained the sedentary lifestyle, and people with depression did not engage in much physical activity or exercise, even at the recommendation of their doctors.[27] Social relationships were also a factor that influenced walking practice. It decreased when there were no family members due to divorce, death, or separation. People who contacted their neighbors and friends less than once a month had low walking practice. Good social relationships can promote walking, as people do not think of walking as just a means of transportation or exercise but as a place of conversation, communication, or time with their companions.[10] Social support from family and friends was also associated with the promotion of physical activity in other studies.[28]

The walking practice neighborhood-level determinants were not significant in rural areas. However, the high proportion of road pavement in urban areas has positively impacted walking practices in urban areas. The proportion of road pavement is the ratio of the length of the paved road to that of the opened road, indicating the condition of transportation facilities in the region. A good construction environment helps promote physical activity, even in the facility itself. It positively affects people's physical activity through emotional and psychological channels, such as comfort and safety.[29] Conversely, in rural areas, where the proportion of road pavement is lower than that of cities, residents walk more along agricultural roads or inside the village than on sidewalks next to roads. Therefore, the proportion of road pavements in rural areas was not considered a walking practice determinant.

In the event of a heatwave, the government distributes emergency disaster text messages containing instructions to the public through mobile phones or mass media. It mainly guides people to refrain from outdoor activities, drink plenty of water and not caffeine-containing drinks or alcohol, not leave the elderly or children alone, move to cool places to rest, and drink cool beverages slowly when they show heat-related disease symptoms.[30] However, these guidelines recommended refraining from physical activity, which may lead to negative effects due to poor physical activity. It is necessary to prevent poor physical activity during high temperatures. Excessive outdoor physical activity during a heatwave can negatively affect one's health. However, maintaining a healthy body through active physical activity improves vascular tone and autonomic nerve function in the cardiovascular system, efficiently controlling body temperature during a heatwave.[31,32] For population groups that are expected to be significantly affected by poor physical activity, such as older adults and chronically ill individuals, it is necessary to maintain activity and exercise rather than compulsory activity restriction to function independently.[20] Methods to reduce the impact of high temperatures should be included, concerning the effect of temperature on physical activity. In addition to running indoor exercise programs, actions for health, such as installing street trees and shade to block sunlight, creating parks and forests to reduce radiant heat and air pollution in the region, and installing safe sidewalks and street lamps, are needed.

This study had some limitations. "Temperature" was the only weather factor that affected walking practice. Weather factors, such as precipitation, humidity, and wind speed, can also affect outdoor physical activity during a warm season; however, these factors were not considered in this study. The Korea Meteorological Administration provides elements, such as precipitation, humidity, air conditions, temperature, lightning, wind direction, and wind speed; however, only temperature data could be used intact without missing values in Gyeongsangnam-do. In addition to meteorological factors, environmental hazards, such as fine particulate matter ($PM_{2.5}$ and PM_{10}), heavy metals (lead, cadmium, chromium, etc.), volatile organic compounds, and polycyclic aromatic hydrocarbons, were not measured objectively.[33] Methods for measuring environmental factors in communities need to be reinforced to accurately assess the impact of environmental factors on residents' health. Precipitation is also an important factor affecting temperature and physical activity; however, precipitation information could not be used in this analysis due to weather data limitations. However, when it rains, the temperature drops and rainy weather interferes with people's physical activity. In this study, which identified the association between high temperatures and poor physical activity, the absence of precipitation information could be a bias that deflects the results to the null hypothesis. Therefore, this study's results without precipitation information may have been underestimated compared with the actual values. Our study targeted small- and-medium-sized cities and rural areas, not large cities. Further research is needed on generalizing large urban areas where public transportation is used frequently in daily life, including subways. The use of public transportation is one of the main determinants that promote people's walking. Well-developed public transportation systems, such as subway, that are well connected to various underground facilities allow people to be less affected by ambient temperature when walking. The elderly population is small, and the environment for indoor activities and exercise is well established.

This study is the first to confirm the association between high temperatures and walking practice in adults in rural and urban communities in Korea. Based on the study results, it was confirmed that temperature rise led to more decrease in physical activity levels in rural areas than in urban. In conclusion, since temperature can reduce physical activity during the hot summer months, physical and environmental approaches to avoid heat are needed to maintain and promote physical activity.

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AUTHOR CONTRIBUTIONS

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